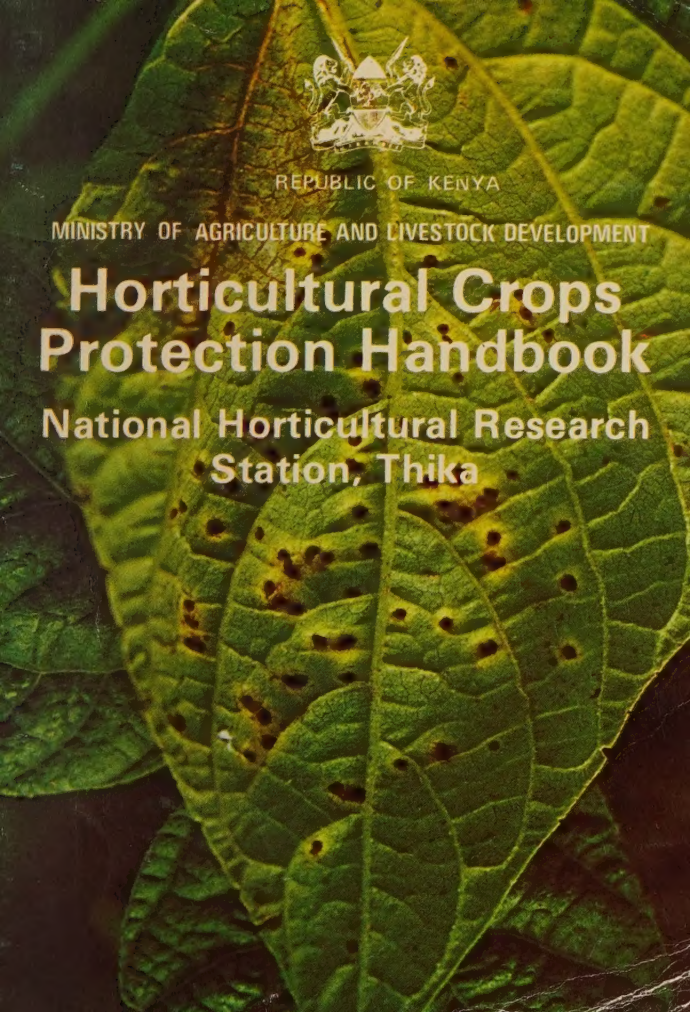

REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

Horticultural Crops Protection Handbook

National Horticultural Research Station, Thika

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Foreword

In an effort to promote the horticultural industry in Kenya, several studies were conducted on various types and varieties of fruits, vegetables and flowers. Although, very promising varieties of the above crops were identified and released to farmers, there is a steady growth of needs to improve the production both in quantity and quality. We are indeed challenged by these needs.

One of the most critical challenges facing the horticultural industry is to devise methods for the economic control of diseases and insect pests. Rapidly rising costs of chemicals and other inputs of production calls for a careful examination of the results in terms of cost/benefit before recommendations are made to farmers. The small farmer who shoulders the responsibility for the production of the bulk of the crops is the first one to feel the pinch.

This handbook is concerned with important diseases and insect pests and is prepared by experts from the results and information obtained in research and experiences gained in the field. The authors have made valuable contribution to the knowledge of horticultural crops protection which will be supplemented in the future. We are sure, the handbook contains sufficient material to be a valuable guide to the extension workers and technical officers in enhancing improvement of the production of the crops in the country. It also serves as a valuable reference for researchers in Kenya as well as to the neighbouring countries with similar situations.

This handbook was initiated by H.A.I. Stoetzer and S.T. Kanyagia, was further developed by A.M. Whittle. The final editing to completion of the handbook was undertaken by A.A. Seif and S.T. Kanyagia. The authors and all others are commendable for their hard work and contribution.

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Introduction

Diseases and insect pests constitute a major contraint on production of horticultural crops in Kenya. Although adequate estimates of losses cannot be made at present, diseases and insect pests do cause great losses in quantity and seriously lower the quality of horticultural crops. Many insect species are also able to spread plant pathogens specially viruses and mycoplasmas in addition to direct damage they inflict to the crops.

Frequently, small modifications in farming practices can be made at little cost, to effectively control pests or diseases. However, where such practices are inadequate and chemical control must be used, it is essential that the correct diagnosis and the proper choice of pesticide be made. This affects not only the economic status of the individual farmer, for whom the cost of pesticides may be a limiting factor, but also the national economy as a whole. In both cases the correct diagnosis of a pest or disease is therefore, the first step in successful economical control of pests and diseases.

These observations have stimulated the specialist staff of N.H.R.S. to select and document in this handbook a series of diseases and pests problems affecting major horticultural crops in Kenya. This series is by no means exhaustive, but is intended initially to cover the most frequently encountered problems. In part, this series also arises from the results of a survey of diseases and pests of horticultural crops conducted by H.A.I. Stoetzer and S.T. Kanyagia (published as Workig Document No. 11 by the F.A.O. Project KEN/75/028).

Where specific pesticides have been mentioned these are generally given as examples and should not be regarded as exclusive of others. Due to the many products commercially available it has not been possible to list all pesticides. Furthermore, mention of certain pesticides does not imply any preference or advantage over similar chemicals not mentioned by name. With the present state of knowledge over the efficiency or cost/benefits of pesticide usage in Kenya it has been also necessary to draw on experience from other countries. Since current research programmes are aimed at giving more detailed recommendations for pest and diseases control, these will be published as supplements in the future.

CONTENTS

GENERAL DISEASES AND INSECT PESTS

D Bacterial wilt 1
Root rot 3
N Root-knot nematodes 5
P American bollworm 7
Red spider mites 9
Serpentine Leafminer 11
Systates weevil 13
Whiteflies 15

DISEASES AND INSECT PESTS OF MAJOR HORTICULTURAL CROPS:

Apple:
D Powdery mildew 17
Scab 19

Avocado
D Fruit spots and rots 21
Root rot 25

Banana:
D Cigar-end rot 27
Panama disease 29
N Burrowing nematodes 31
P Banana silvering thrips 33
Banana weevil 35

Bean:
D Angular leaf spot 37
Anthracnose 39
Common mosaic 41
Halo blight 43
Rust 45
P Beanfly 47
Bean bruchids 49

Brassica:
D Black rot 51
Ring spot 56
P Cabbage aphids 53
Diamondback moth 57

Brinjal:
D Powdery mildew 59
Leaf spot 61

Capsicum:
d Leaf spot 62
Anthracnose 63
Leaf spot 63
Mosaic 65
Powdery mildew

Carnation:
D Alternaria blight
Fusarium wilt 71
Rust 73

Carrot:
D Alternaria blight 75

Cashew:
P Helopeltis 77

Citrus:
D Greening 79
Gummosis 81
Scab 83
Tristeza 85
N Citrus nematode 87
P Aphids 89
Black Fly 91

False codling moth 93
Fruit Flies 95
Orange dog 97
Psyllid 99
Scales 103

Coconut:
D Lethal bole rot 107
P Rhineceros beetle 109

Cucurbits:
D Downy mildew 113
Powdery mildew 115
Virus diseases 117

Grape-vine:
D Downy mildew 119
Powdery mildew 121

Mango:
D Anthracnose 123
Powdery mildew 125
P Seed weevil 127
White scale 129

Onion:
D Downy mildew 131
Purple blotch 133
P Thrips 135

Passion Fruit:
D Brown spot 137
Woodiness virus 139
P Bugs 141

Pawpaw:
D Decline 143
Powdery mildew 145

Peach:
D Leaf curl 147

Peas:
D Powdery mildew 149

Pineapple:
DP Mealybug wilt 151

Strawberry:
D Grey mould 153
Leaf spot 155

Tomato:
D Bacterial canker 157
Bacterial spot 159
Blossom end rot 161
Early blight 163
Late blight 165
Leaf spot 167

PESTICIDES 169

P — Pest
D — Disease
N — Nematode

Bacterial Wilt

Pseudomonas solanacearum (E.F. Smith) E.F. Smith

Symptoms The symptoms are rapid wilting and death of the entire plant, unaccompanied by any yellowing or spotting of the leaves. All the branches wilt at about the same time. If the stem of a wilted plant is cut across, the pith has a darkened, water-soaked appearance and there is a greyish, slimy exudate when the stem is pressed. In later stages of the disease, decay of the pith may cause extensive hollowing of the stem. Bacterial wilt causes no spotting of the fruits. Affected roots decay, becoming dark brown to black in colour. If the soil is moist, diseased roots become soft and slimy.

Biology *P. solanacearum* is soil-borne and it infects the plants through the roots. It is most active at temperatures above 24°C and is especially destructive in moist soils. All members of Solanaceae (potatoes, brinjals, capsicums, etc.) are susceptible to wilt. As the roots of wilted plants decay the bacteria are released back into the soil.

Control It is important to avoid growing seedlings in beds where the disease has occured. If plants in the field are seen to wilt, they should be immediately removed to minimize the build up of bacteria in the soil. A rotation of at least three years should be practised, making sure that tomatoes do not follow related vegetables (Solanaceae) in the rotation. No resistant varieties are commercially available at present.

Root Rot

Armillaria mellea (Vahl.) Pat.

Symptoms A number of fungi are able to attack roots and it is often difficult to distinguish between them in the field. For this reason it is advisable to seek the opinion of a specialist before a diagnosis is made. *Armallaria mellea* has a very wide host range, particularly woody plants and trees. Amongst hosts of commercial importance on which the disease has been diagnosed or suspected in Kenya are *Acacia, Cupressus, Eucalyptus,* Citrus, Avocado, macadamia, Pinus, tea, coffee and *Cinchona.*

Several of the diagnostic features by which *A. mellea* is identified in temperate countries are black rhizomorphs,

resembling shoelaces, in the soil and under the bark, the mushroom-like fruiting body, and black lines in affected wood. These characters, however, are not regularly found in the tropics.

Above ground symptoms of yellowing of the foliage, withering and leaf drop, are only seen when root damage is already extensive, but these symptoms can be caused by other disorders. In cases of *A. mellea*, upon excavation of the base of the tree and the roots, fan-shaped sheets of white fungal mycelium can be found between the bark and the wood. The bark has a soft, spongy texture and affected tissue has a distinct 'mushroomy' smell

Biology Healthy trees are rarely attacked, except when their roots come into contact with the roots of previously felled trees. The fungus colonizes old tree stumps and survives there saprophytically, though it is not very competitive with other wood destroying fungi. Once it has colonized the root of a growing tree it can spread rapidly along the root to the base of the tree from where it can colonize the major part of the root system.

Control Once the disease has become established in a tree it is very difficult to control and steps should be taken to avoid initial infection. When the land is being cleared of trees prior to the planting of an orchard, the existing trees should be ringed so that they die slowly and stored carbohydrates in the stump and roots are exhausted. After felling, the stumps and as much of the root system as possible should be removed. Where slight infection of the root system is suspected the soil around the base of trees should be excavated to expose the point of contact between the roots and the crown, as growth of the fungus is inhibited by exposure to the air. If infection has already reached the crown, surgical removal of the affected area, followed by treatment with a wound paint may be successful.

Root-knot Nematodes, or Eel-worms

Meloidogyne spp.

Symptoms Above ground symptoms of attack by these nematodes are stunting and yellowing of plants with a tendency to wilt in hot weather, though root infestation is not always apparent on the above ground parts of the plant. If infested plants are pulled from the soil the roots can be seen to be severely distorted, swollen and bearing knots which should not be confused with the desirable nodules on the roots of legumes. On root crops such as carrot or potatoes the most conspicuous symptoms are the raised bumps on the roots or tubers. In all crops heavy infestations result in a severe loss of yield and a reduction in quality.

Biology Four species of root knot nematodes *(M. hapla, M. javanica, M. incognita* and *M. incognita acrita)* occur in Kenya and particular species are well distributed throughout the vegetable growing areas, being most serious in irrigated areas. A vast number of crops and weeds can act as hosts.

The young nematodes (larvae) move through the soil and enter roots and tubers where they continue development to adulthood. Two or three generations may develop within a season. Whilst nematodes may travel short distances through the soil they are spread from field to field by irrigation water, by soil or animals, and by infested tubers.

Control The numbers of root-knot nematodes can be reduced by several simple agricultural practices. As many weeds harbour them, there should be careful weeding, particularly in such highly susceptible crops as tomatoes, brinjals and beans. When harvesting is complete the entire plant should be uprooted and destroyed. Where possible a dry fallow is effective, particularly if it follows ploughing or digging to expose deep-seated nematodes to lethal temperatures and dessication.

Crop rotation with grasses, maize or cereals may be helpful in reducing infestations, but this depends on the nematode species involved. Specialist advice should be sought on identification.

Care should be taken not to introduce nematodes into farms by obtaining seedlings from other infested sources.

Chemical control can be costly, and difficult for the smallholder. In finely worked soil DD (Dichloropropane-dichloropropene) or EDB (Ethylene dibromide) can be applied by injection at least three weeks before planting. Other chemicals, available in granular form to be mixed with the soil at planting, are Furadan and Nemacur but should not be used on short season vegetables because of their persistence in crops for six to seven weeks.

American Bollworm

Heliothis armigera(Hubn)

Symptoms: The nature of damage is similar in all host plants. Both young and old caterpillars bore into the fruits, floral buds and even flowers. While feeding, the caterpillars rarely enter the plant tissue entirely. Usually the hind part of the body is exposed outside. Feeding caterpillars produce copius amount of excreta which are easily visible on the surface of the attacked plant part. One caterpillar is capable of destroying several fruits, pods, etc., as it moves from one to another. The feeding holes made by the caterpillars serve as entry points for bacteria and fungi, which may cause rotting of the attacked parts.

Biology The genus *Heliothis* occurs in a wide range of climatic conditions, extending about 45° of latitude on either side of the Equator and includes some of the most important species of both fruit and vegetable crops. Within the genus *H. armigera* is the most important pest in the old world, while *H. zea* and *H. virescens* replace *H. armigera* in the Americas. Although *H. armigera* is commonly known as American bollworm, it does not occur in America. The pest attacks a

wide range of plants, both wild and cultivated, with the larvae showing preference for fruits and floral buds.

The eggs are laid singly, usually on young plant tissue or developing fruits. The eggs are somewhat spherical, measuring about 0.5mm in diameter. Freshly laid eggs are yellowish white but they turn brown as the embryo develops. Eggs hatch after 2 to 4 days The caterpillars measure up to 4cm in length, and bear a characteristic undulating white band on each side of the body. The colour varies from black to green, brown, reddish-brown, whitish and orange, but some shade of green or brown is always noticeable. The body is marked with alternating longitudinal dark and light bands. The caterpillar undergoes six larval instars, the entire larval life lasting three weeks. Pupation takes place in the soil. The pupa is shiny brown and about 16mm long. The pupal period lasts 10-14 days depending on temperature.

The adult moth is dull brown with rounded wings and a wing span of about 35mm, appearing mainly in two colour varieties having brown or grey forewings respectively. The female moth is attracted to flowers, is an active flier and is nocturnal in habit. The oviposition period lasts 10 days during which the adult female lays between 750-1000 eggs.

Control Spraying should be done as soon as young caterpillars are noticed on the crop since control becomes increasingly difficult with older caterpillars. Control can be achieved by using such chemicals as Endosulfan, Fenthion, Trichlorphon or synthetic pyrethroids. In addition, tasseling maize can be used as a trap crop, since it is very attractive to ovipositing females, but this can only be possible if the host plants' flowering and fruiting is synchronised with the tasseling of the maize. The tassels should be sprayed regularly with any of the above insecticides, especially after the caterpillars have been noticed on the tassels. A few Hymenopteran and Dipteran (tachnid) parasites have been recorded in Kenya but their role in controlling the pest has not been evaluated.

Red Spider Mite

Tetranychus spp. (Acarina: Tetranychidae)

Symptoms The mites feed in clusters on the underside of the leaves, especially between the main veins. The attacked leaves assume a stippled appearance, turning yellowish to whitish, dry and fall to the ground. Cast skins of the larval and nymphal stages remain stuck to the leaf and may be seen as irregular white specks. Under severe infestations fine webs spun by adults will be found covering the leaf surface. The pest is mainly important during dry weather spells.

Biology The pest has a wide host range including both cultivated and wild plants. The eggs are spherical and whitish, and are laid singly on the underside of leaves or on

strands of silken web spun by the adult mites. Hatching occurs after 4-7 days.

The larva is six-legged, pinkish in colour and slightly larger than the eggs. Larval life lasts 3-5 days. This is followed by a nymphal life which has two distinct stages, i.e. protonymph and deutonymph. Both stages are 8-legged and greenish to reddish in colour. The entire nymphal life takes 6-10 days. The adult females measure 0.4-0.5 mm in length and are slightly larger than the males. Both males and females are oval in shape and appear reddish or greenish. Adult females live for about three weeks during which time they may lay up to 200 eggs.

Control The predacious mite *Phytoseilus viegeli* has been used in control Tetranychus spp. in greenhouses in N. America and Europe with success. The same has been introduced in the field in Uganda and Kenya, but poor control was obtained. Several acaricides are capable of controlling the red spider mite in the field, such as Dicofol Dimethoate, or Chlorobenzilate.

Serpentine Leafminer

Liriomyza trifolii Burgess

Symptoms Silvery tunnels appear on the upper leaf surface, where leafminer larvae are feeding just beneath the cuticles. As the larva grows, the tunnel becomes wider, with a line of excreta in the middle. Later, the affected area dries.

Heavy infestation will turn leaves necrotic and eventually the whole crop may die off.

Biology The serpentine leafminer has only recently been recognised in Kenya as a very serious pest on many vegetables, legumes, ornamentals and wild plants. Affected crops include tomatoes, brinjals, peas, cucurbits, beans, potatoes and *Chrysanthemum*. In recent years the leafminer

has invaded many different crops in East Africa. In Kenya it was first recorded at Kibwezi, where it destroyed the *Chrysanthemum* industry. The adult insect is a small fly, about 2mm long. The upper part of the body is mainly dark, but the scutellum, legs and body sides are yellow. The development cycle, from egg-laying on the leaf to emergence of the fly, takes 21-28 days on *Chrysanthemums.*

When the yellow-brown larva is fully grown, it usually leaves the plant, falls to the ground and pupates in the soil.

Control Control of the leafminer seems very difficult and research in Kenya on this subject has not been concluded yet. Many commonly used insecticides have been ineffective, but frequent spraying with extremely poisonous chemicals control this pest to an extent. Control trials elsewhere have produced some positive results using frequent applications of synthetic pyrethroids, Malathion, Methomyl, Trichlorfon, Dichlorvos or Fenitrothion. Repeated spraying, however, tends to induce resistance of the insect pest, while killing off natural enemies. So far, three different parasites of the leafminer have been identified in Kenya, but their importance is not yet known. The pest incidence seems to follow a certain periodicity which is still under study.

Systates Weevil

Systates Pollinosus (Gerst)

Symptoms This leaf-eating weevil feeds at night on the edges of leaves, leaving characteristic indentations. A wide range of wild and cultivated plants can be affected, including most fruit tree crops and coffee. Damage is usually restricted to nursery stock or newly transplanted seedlings of citrus, avocado, macadamia, mango and pawpaw. In apple orchards, however, this pest can do much harm by feeding on the blossom, thus destroying the future crop.

Biology The systates, or citrus weevil is black in colour and about 1-1.5 cm long, with a rather swollen abdomen. It cannot fly and is rarely seen during daytime when it hides in

the mulch, loose soil near the plant, or under bark or in termite tunnels. Only early in the morning may one find the weevil motionless on the nursery plants. The immature stages of this insect are not well-known but are believed to occur in the soil.

There are no records of natural enemies affecting the weevil in Kenya.

Control Most fully grown orchard trees do not need any protective measures, but nursery stock, young orchard trees and apple trees may need control measures. Small plants can be checked during early morning hours, picking the weevils by hand. For bigger trees one may use sprays of Endosulfan or Fenitrothion, wetting foliage, stem and the soil surrounding the stem base.

Whiteflies e.g. *Bemisia tabaci (Genn)* - **(Tobacco Whitefly)**

The group of insects generally referred to as whiteflies is composed of 1156 species in 126 genera, but one species, *Bemisia tabaci*, of particular importance in Kenya is dealt with as an example of the group.

Symptoms Small, white, scale-like insects cluster on the underside of upper leaves, from which they suck sap. Whilst this damage is not always readily apparent, in cases of high pest population it may be sufficient to cause slight wilting of leaves. *B. tabaci* is a vector of many virus diseases and often the resulting virus symptoms obscure those caused directly by the insects. Among the important viruses transmitted by

B. tabaci are cassava mosaic, cotton leaf curl, tobacco leaf-curl and sweet potato virus B.

The adults characteristically fly from the plant as soon as a leaf is disturbed.

Biology Some of the host plants are indicated above from the list of viruses transmitted, but many other cultivated and wild plants are attacked.

The eggs, pear-shaped and measuring about 0.2 mm, are laid on the underside of the leaf and are anchored by a stalk at the larger end. They are white when first laid but later turn brown. Hatching takes place in 7 days.

On hatching, the nymphs crawl for a short distance before settling down to feed. The nymphal instars are greenish-white, oval in outline and resemble scales. The second, third and fourth instars are immobile. The fourth instar normally referred to as the 'pupal case', measures 0.7 mm in length and the developing adult is visible through the transparent integument. The nymphal period lasts 2-4 weeks, depending on temperature.

The adult, which has four wings and measures about 1 mm, emerges through a slit in the pupal skin. It is covered by a white, waxy secretion. One female lays about 100 eggs.

Control If necessary, whiteflies can be controlled by spraying with Diazinon, Dimethoate, Trichlorphon or pyrethrum or synthetic pyrethroids.

Powdery Mildew

Podosphaera leucotricha (E. & E.) Salmon

Symptoms The symptoms to a certain extent depend on the susceptibility of the variety. In a highly susceptible variety, such as Rome Beauty or Jonathan, infection starts as white, felty patches especially at the leaf margin, later extending over the whole leaf surface and down over the entire shoot. The leaves may be narrower than normal and distorted and may fall prematurely. In a more resistant variety, such as Delicious, all that may be seen are pale spots with reddish borders.

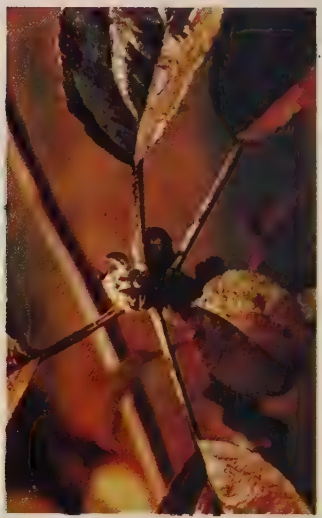
In susceptible varieties all parts of the blossom may be covered by a powdery white growth and the fruit may then

fail to set. When shoots are infected they may be stunted and show an increased susceptibility to low temperatures with the result that in temperate countries they may be killed in winter, but in Kenya the shoots usually survive to become an inoculum source with the appearance of the next flush.

Biology As indicated above the fungus may survive from one crop to the next in infected shoots, but it also survives on inner bud scales. Apple mildew is most active at 21°C but thereafter decreases markedly with the increase in temperature. As with many mildews, dry days and dewy mornings are conducive to disease development. Pears are also attacked by this disease.

Control Vigorously growing trees are more resistant to mildew, although an excess of nitrogen is favourable to the disease.

Whilst, theoretically, sprays should be applied to coincide with leaf appearance, in practice, mildew sprays are often combined with scab sprays. Care should be taken with sulphur as some varieties are sensitive (e.g. Delicious); sulphur-tolerant varieties include Rome Beauty and Jonathan. Alternative fungicides for any variety include Dinocap, Bupirimate, Pyrazophos and Binapacryl. Benomyl as a soil drench is effective on nursery stock.



Scab

Venturia inaequalis (Cke.) Wint.

Symptoms On the leaves, scab infection first shows as a poorly defined velvety brown or grey spot 1 cm or more in diameter, usually on the upper surface. If the leaves are not sufficiently severely infected to drop prematurely, the spots become slightly raised and smoother. Occasionally the resulting dead tissue falls from the leaf leaving irregular holes.

Similar velvety spots may appear on the flower sepals and from there infect the developing fruit. At first the fruit lesions are small and raised, but without a break in the skin. As they increase in size these lesions rupture and result in a corky

canker, from which the disease gets its name. These scabs are usually more numerous at the calyx end of the fruit and may result in deformation or splitting of the fruit. Occasionally twigs may be infected.

Biology The main source of inoculum is the spores (ascospores) produced on dead leaves on the ground. Other spores may be produced on infected twigs but these are usually of minor importance. Later development of the disease arises from spores produced on the leaves and fruits still on the tree.

The ascospores on the dead leaves occur at any temperature between 5° C and 26°C, but water is required. The length of time when free water is required decreases with increasing temperature, so that at 20°C (the optimum temperature) the time required with water on the leaves is 4-6 hours. Secondary infection can occur at any time during wet periods.

Control The most important aspect of the control of scab is the prevention of the primary infection at flowering time. A fungicidal spray should be applied just as the flower bud scales separate, and a second spray when most of the petals have fallen. Further sprays may be needed as the fruit develops if wet conditions prevail for any length of time. Benomyl can be used, which also controls mildew, or Captain or dithiocarbamates, though this list is not exclusive. As in many cases the use of Benomyl should be monitored for resistance development.

Fruit Spots and Rots

Sphaceloma perseae Jenkins, *Cercospora purpurea* Cke and *Colletotrichum gloeosporioides* Penz.

Symptoms (1) Scab *(S. perseae).* Although all three diseases also attack the leaves their prime importance lies in the damage done to fruits and only this aspect will be dealt with. Scab lesions on young fruits are small and slightly raised, resembling some scale insects, but as the fruit matures they enlarge to form shining dark brown patches surrounded by a thin grey area. These patches may coalesce to disfigure much of the fruit surface and the scab tissue may crack, providing a point of entry for the anthracnose fungus.

(2) Cercospora spot *(Cerc. purpurea)* The lesions are first seen as minute pale green, slightly raised spots which gradually become reddish brown and sunken, about 2 mm in diameter. These spots eventually become hard and crack.

(3) Anthracnose *(C. gloeosporioides).* A much larger lesion than the first two and it appears as the fruit approaches maturity. The spot, about 5 - 10 mm in diameter, is black and slightly depressed and covers a rot of the flesh which can penetrate deep into the fruit. In wet weather the spot may be covered with masses of slimy, salmony pink spores. As a result of infection the fruits ripens and falls prematurely. The disease may develop very rapidly in storage.

Biology (1) Scab. Fruits are only susceptible from flowering until about half size development. The fungus requires moist conditions for sporulation and infection so the fruits may escape infection when the conditions at fruit setting are dry and warm.

(2) *Cercospora* **spot.** Spore production occurs under very humid conditions and when the temperature is high, 30° C being the optimum, though sporulation readily occurs above 20° C if high humidity exists. Spores are essentially splash dispersed, though under wet conditions they can also be wind borne. Infection is through lenticels. Mature fruits are resistant. Symptoms are rather slow in appearing, often as much as three weeks after infection.

(3) Anthracnose The fungus lives saprophytically on twigs, rotten fallen fruits and dead or dying leaves but is generally unable to infect undamaged fruits. During wet weather, when the fungus sporulates, the spores are spread by splash and infect only damaged fruits.

Control Avocado varieties differ in their susceptibility to scab, with Fuerte being regarded as susceptible. Because of the time span during which avocado fruits are susceptible to these diseases, each appearing later than the other, any spray programme should cover much of the development period of the fruit. The first spray should be applied when the flower buds appear, followed with sprays when the fruits set and then a month later. Copper based fungicides are normally used.

Although copper can be used to control *Cercospora* spot, Benomyl is also recommended; sprays should be applied every 7 - 14 days, depending on the rainfall. In dry conditions the interval can be extended. If control of scab and *Cercospora* spot has been inadequate and anthracnose becomes a problem it may be reduced by dithiocarbamate fungicides. In all cases it is important that the sprays should reach the tops of the trees. Further, as the fungus causing anthracnose survives on dead twigs, etc. these should be regularly removed from the tree.

AVOCADO

Root Rot

Phytophthora cinnamomi Rands

Symptoms Trees of any size, from nursery trees to large, old trees, may be affected. Leaves of infected trees are smaller than normal, usually pale or yellow green instead of dark green, are often wilted and fall prematurely to give the tree sparse appearance. New growth is often absent but if new leaves are formed they are small and pale green. In advanced stages of the disease, branches die-back and fruit remains small. Feeder roots on diseased trees are blackened, brittle and dead. As the absence of feeder rootlets prevents the uptake of moisture, the soil under diseased trees tends to stay wet. Diseased trees die prematurely.

Biology The fungus thrives best in soils with excess moisture. It can be spread or introduced to new areas by infected seed, infested soil, movement of irrigation water containing spores of the fungus and with balled or container-

grown plants. Seed infection may occur if the fruit is allowed to remain for several days on soil infested with the fungus The host range of the fungus includes *Acacia, Casuarina, Camellia, Cupressus, Eucalyptus* and *Grevillea*

Control Preferably all seed used for planting should be taken from fruit picked from the tree. Avocado seed that is picked from the ground must be treated in a hot-water bath at 48° C to 50°C for 20 minutes. After the hot-water treatment, the seeds should be rinsed immediately with clean, cold running water and spread out to dry thoroughly on a clean surface not in contact with the soil. Clean nursery soil must be used for container-grown plants otherwise even treated seed will become infected. The soil should be well drained and carefully irrigated to prevent excessive moisture in the soils Equal care should be exercised in selecting ornamental plants for planting near an avocado orchard, as the fungus attacks many other woody plants and can be brought to a property in infected stock.

If the avocado orchard is infested with root rot fungus, all severely infected trees should be removed and all precautions taken to prevent movement of soil or water from diseased areas to noninfested areas. Cultivation equipment should be used in the healthy portion of the orchard before use in the diseased portion, thereby preventing the spread of infested soil. Equipment should be washed and dried thoroughly after use in the diseased section. The diseased area should not be irrigated. It is provisionally recommended to soil drench the newly infected trees (starting to show root-rot symptoms) either with Metalaxyl (10 ppm at monthly intervals) or Phosethylaluminium (50 ppm, weekly). Moderate resistance to root-rot has been found in California, USA, in rootstock varieties Duke (No. 6 and 7) and G6 (a selection from Guatemala). The standard rootstock variety in Kenya is Puebia which appears to be moderately susceptible.

Cigar End Rot

Verticillium theobromae (Urc) Mason

Symptoms The disease is typified by a dry rot with an ashy appearance of the fruit tips; hence the name cigar end rot. The rot normally affects a few centimetres of the tip. The pulp undergoes a dry rot and becomes fibrous.

Biology The fungus saprophytically invades the dried flower parts and penetrates into the fruit skin producing a dry rot. High humidity favours the development of the disease. Poorly maintained plantations with overcrowding of plants and abundant leaf trash favour disease incidence because of the high humidity and heavy inoculum source.

Control Where the disease is regularly observed hand removal of all dried floral parts from fruit tips is recommended. The flower parts should be removed 8-11 days after fruit bunch emergence. At this stage they can easily be brushed off by hand. All excess dried leaves and other dead plant tissue should be removed from the plantation and burned. Proper spacing between plants should be maintained by pruning out excess suckers. Chemical control is probably not economically feasible unless fruits are grown for a high grade market where missing fruits detract from the appearance of the bunch.

Panama Disease (Fusarium Wilt)
Fusarium oxysporum f. sp. *cubense* (E.F. Smith)
Snyder & Hansen

Symptoms External symptoms consist of a yellowing of the older leaves, or collapse of these leaves while still green at the junction of the petiole with the pseudostem. Sometimes the unfurled heart leaf dies. All leaves eventually collapse and die but the pseudostem remains standing until it decays and falls over. Internal symptoms consist of vascular discolouration in the outer leaf sheaths and may extend throughout the pseudostem and fruit stalk. Vascular discoloration is most pronounced in the rhizome. Fruits do not show any symptoms. Young suckers are seldom affected

and may escape infection to produce a normal fruit stem. Diseased plants fail to produce normal fruit and usually die before the fruit stalk is fully developed.

Biology The fungus is soilborne, surviving in banana debris in the soil, and infection occurs through the fine roots. It is spread through infested soil, and by infected or contaminated rhizomes or young plants transported from one area to another. Local spread can occur along river banks by soil movement during flooding.

Control Apart from the use of resistant varieties there is no other means of control except by stopping movement of banana planting material from affected to non-affected areas. All varieties of the Lacatan Cavendish group are resistant to wilt. In Kenya, resistant varieties include Kisigame (Synonyms: Shisikame, Linyole), Muraru, Ikiganda and Manyoke. Mutahato (or Mutavato) à cooking type, is also resistant. One of the best sweet varieties, Bogoya, is susceptible to wilt. Resistant substitutes for Bogoya are a dwarf Cavendish type called Sukari, Chinese dwarf, Cabou, Somali, Kimalindi, Kigumi, Pikipiki or Gatumia.

Burrowing Nematode

Radopholus similis Cobb

Symptoms The burrowing nematode is a serious pest of bananas in Coast, Western and Nyanza Provinces where a marked yield decline has been observed. Most banana varieties are affected. The first above ground symptoms are yellowing of the leaves; later, growth ceases and the rhizome development is retarded and, finally, mature plants may topple.

In advanced stage of infestation, root examination will show brown lesions on the roots, especially near the rhizome. These brown lesions are particularly clearly seen when an affected root is split longitudinally and examined immediately.

Biology All stages of the nematode can be found in the root region of the plant. Eggs are laid in infested tissue and the generation time, from egg to egg, is 20-25 days in soil temperature similar to those at the coast.

The nematodes can be spread locally in irrigation water or soil particles, but the most important means of spread is on rhizomes for planting.

Control The most important aspect is the planting of rhizomes free from *R. similis*. Where this is not possible the planting material can be improved by the cutting out and trimming of lesions, or by immersing the rhizomes in hot water (55°C) for 20 minutes. Trimming and hot water treatment, however, often fail to eradicate all the nematodes and then numbers can build up fairly rapidly again after planting.

Soil fumigation can be used where planting in infested soil is unavoidable. D-D (dichloropropane-dichloropropene) or EDB (Ethylene dibromide) applied three weeks before planting will give satisfactory results. Carbofuran and Phenamiphos applied at the time of planting can also be used.

Banana Silvering Thrips

Hercinothrips bicinctus (Bagnall)

Symptoms The nymphs feed on banana fruits, producing silvery patches which later turn brown and are covered with dots of black excrement. Under heavy infestation, the skin of the fruits may crack longitudinally permitting the entry of fruit rotting bacteria and fungi. The damage to the fruit is normally superficial and of little significance on the local market. For the export market, however, the appearance of fruit is important.

Biology The pest is recorded only on bananas. The adult thrip inserts its eggs into the fruit tissue, especially where two banana fingers touch.

The nymphs are yellowish with swollen abdomen which appear black due to the presence of liquid excreta in the gut. A fully grown nymph is about 1 mm in length. The adult is dark brown and about 1.5 mm with 2 pairs of fringed wings. The pest has no recorded natural enemies in Kenya.

Control Normally chemical control in bananas is limited by the size of the crop and density of the foliage together with lack of appropriate spraying equipment. In a properly maintained orchard, however, where pruning and thinning are regularly done application of chemicals to the fruits is feasible. Carbaryl, Dichlorvos or Fenthion may be used but consideration should be given to the economics of control.

Banana Weevil

Cosmopoljtes sordidus Germ

Symptoms The larva (grub) feeds on the rhizomes and pseudostem at ground level, making irregular tunnels. An infested rhizome is eventually reduced to a blackened mass of tissue. In some cases the tunnels may extend one to two metres up the pseudostem.

The leaves turn yellow, wither and die prematurely. Infested plants are easily blown over by wind. Death of the heart leaf is also an indication of weevil damage.

Biology The insect attacks banana and plantains. The adult female weevil lays single eggs in small pits made in the pseudostem near the ground level. The white eggs, which

are elongate - oval, 2-3 mm in length, hatch in 5 - 8 days.

The grub is creamy white, stout, legless with a distinctly curved body swollen in the middle. Larval life lasts 14 - 21 days.

Pupation normally takes place in the tunnels. The pupa is about 12 mm long and white. The pupal life lasts 5 - 7 days. The adult weevil is black or brown-black, about 12 mm long, hard shelled and with a pronounced curved snout. The weevils hide during the day in or around the corms or between leaf - sheaths above ground level and emerge at night to feed and lay eggs. They are very sluggish and feign death when disturbed. The weevils are long lived, and egg - laying continues throughout the year.

Control Use of pest-free suckers, cut old stems to ground level and cover the stumps with compacted soil. Dip suckers in a solution of Dieldrin 18% EC (40 mls in 10 litres of water). Dust with Dieldrin 5% or spray with Dieldrin 18% EC at least 3 times a year around the base of stems. Place traps (baits) consisting of pieces of old pseudostems, 40-60 cms in length and treated with Dieldrin 18% EC.

Angular Leaf Spot

Phaeoisariopsis griseola (Sacc) Ferraris

Symptoms Lesions may first be seen on the primary leaves but infection does not usually become apparent until flowering or pod set. At first the lesions are greyish areas on the under-surface of the leaf, then becoming brown and are typically angular and well defined due to delimitation by the veins. The same brown necrotic lesions are then seen on the upper surface also, but it is only on the under-surface that the fungus sportulates by means of small columns of fungal tissue (synnemata) which are characteristic of this disease. If the lesions increase in size they may eventually coalesce, followed by yellowing of the leaves and subsequent premature defoliation.

On stems and pods there are reddish brown, oval to circular spots and, in heavily infected pods, the seeds develop poorly.

Biology The fungus is seedborne but, more importantly, it survives on bean debris for long periods, from where it is dispersed by splash or wind. Once established in a crop, the disease is usually spread by wind from lesions on the foliage. Infection and disease development are encouraged by high humidity or moisture and are most prevalent between 20°C and 25°C.

Control Crop rotation and the removal of bean debris help considerably in reducing the disease. Where it is thought that seed may be infected, such as home — saved seed from an infected crop, dusting the seeds with Benomyl provides good control.

Spraying with chemicals can be economical when infection is severe and dithiocarbamates or Benomyl, amongst others, may be applied. Alternatively, a tolerant variety, such as GLP2, may be grown.

Anthracnose

Colletotrichum lindemuthianum (Sacc & Magn) Bri. & Car.

Symptoms: Bean anthracnose is seedborne and diseased seedlings may be produced from infected seed. Pale brown sunken spots become visible on the cotyledons and water may spread the infection to the hypocotyl which, if girdled, results in the death of the seedling. Lesions on the leaves are dark brown areas along the veins on the underside of the leaf, sometimes extending to the petiole, causing the leaf to drop.

The pod symptoms are the most characteristic and also the most important. On the pods the fungus produces black, sunken lesions, which in damp weather, become covered

with a pink spore mass. With the aid of a magnifying glass, tiny black hairs are visible in the lesion. These lesions penetrate deep into the pod, as far as the seeds, and may cause shirvelling of young pods. On mature pods the lesions finally develop a slightly raised black border with a thin, reddish brown margin. When the infection is sufficiently aggressive to reach the seeds, they become discoloured, from yellow through brown to black, on that portion of the seed in contact with the pod lesion.

Biology: The fungus survives on plant debris or infected seed, for at least 2 years on the latter. Spread is by splash, wind or mechanical contact, and it occurs in cool, damp weather. The optimum temperature for disease spread lies between 7°C and 24°C.

Control The use of home-grown seed can be very risky when seed is collected from a crop where anthracnose was abundant. If such practice is necessary, care should be taken to eliminate obviously discoloured seeds by careful sorting. As seed infection is largely internal, fungicidal treatment is not highly effective. Because of the survival in debris, the usual recommendations of field sanitation and rotation also apply, where possible. As the spores are produced in damp or wet weather, picking or cultivation of the crop should be avoided at this time.

Many races of this pathogen occur, but their prevalence in Kenya is not well understood. Varieties of beans are selected for their resistance to anthracnose and resistance is likely to be the main method of control. Where the disease does occur, the crop may be sprayed with Captan or dithiocarbamates.

Common Mosaic

Bean Common Mosaic Virus (BEMV)

Symptoms of this disease vary with the variety, the growth stage and environmental factors. The disease is seed-borne and aphid transmitted. Leaf symptoms vary with the infection source.

Where the plant grows from infected seed the leaves generally show a pattern of dark and light green areas, with the lighter areas towards the margin. The leaf margin also characteristically curves downwards.

When the plant is infected by aphids the mottling and downcurvng do not occur, but the leaves are chlorotic and stiff with a tendency to droop.

With both infection sources an excessive number of lateral shoots are produced. In general, the symptoms become less obvious as the plant matures.

Biology A number of aphid species can transmit BCMV and are responsible for the spread of the disease within the crop. Initial infection, however, occurs through the seed. In general, earlier formed pods produce a higher proportion of infected seeds than do later ones, though in either case both healthy and infected seeds may be found in the same pod. When infection of the plant by aphids occurs after flowering the seed does not become infected.

Control Control of aphids in bean crops with insecticides (see Brassica aphids) will reduce the spread of the disease but healthy seed is the prerequisite. Varietal resistance is an important control measure, but, being a virus disease, no chemical control exists.

GLP 2 is somewhat tolerant, as is GLP X-92, although the latter may show severe symptoms. Resistant dry bean cultivars will be released in near future. Beans interplanted in maize are normally less affected than those in pure stands.

Halo Blight

Pseudomonas syringae pv phaseolicola (Berkholder Dowson)

Symptoms Halo blight is one of the most serious diseases of beans in the wet and cool areas of Kenya, e.g. Kisii, and derives its name from the characteristic spots which it forms on leaves. The spots consist of a central, semi-transparent and watersoaked area about 0.5 cm in diameter and surrounded by a pale green or yellowish halo up to 2-3 cm in diameter. When infection is heavy the spots may coalesce and dry up so that much of the leaf turns brown and withers. In hot weather the spots may be less characteristic, being reddish brown and lacking a halo, at which point it could be confused with bacterial brown spot. On young plants lesions on the stems appear as reddish streaks which may split and exude a bacterial slime in damp weather.

Other symptoms are noted when the disease originates from infected seed. A water-soaked, yellowish brown lesion forms at the final stem node which may snap when the weight of the plant increases. The growing point may be damaged leading to a proliferation of shoots with overall dwarfing of

the plants. In such systematically infected plants the leaves are yellow with conspicuous green veins, suggestive of mosaic virus infection.

Lesions on the pods are often zonate, sometimes surrounded by a reddish brown margin and often with a white crust of dry bacteria. Lesions on the pod joints lead to seed infection through the vascular system. Infected seed can be detected by the raised blisters of a lighter colour on the seed coat and are particularly pronounced on dark purple varieties.

Biology Spread of the bacteria is primarily through splashing from exuding lesions, they enter the plant through the stomata or through injury sites. Some carry-over of the disease can occur in debris, but infected seed is considered to be the most important inoculum source. Symptoms are most prevalent at temperatures of 16-20°C, whereas at higher temperatures they are less pronounced but the bacterial population remains high.

Control Only clean, certified seed should be sown, or seed originating from a dry area. As with most bacterial diseases, chemicals are generally unavailable for control, although copper oxychloride has an effect for a limited period, and may be of value on French beans. By far the most important control measure a farmer can take is to closely examine his seed lot and remove any obviously discoloured seeds. Inevitably some infected seeds will escape this examination, the then infected plants should be rogued immediately symptoms are seen, and hopefully before they become infective. Where the disease has occurred in a crop, care should be taken to destroy, by burning, the plant debris, rather than to plough it into the soil.

There is a likelihood that varieties with resistance to this disease may gradually become available, although some tolerance already exists in unimproved local lines. GLP 2 is tolerant, while GLP x-92 is resistant.

Rust

Uromyces appendiculatus (Pers.) Unger

Symptoms It should not be possible to confuse this disease with any other on beans. Soon after infection, small, white, slightly raised spots are formed on the under surface of the leaf and eventually these rupture to form typical rust pustules, which are reddish brown due to the mass of spores (uredospores) produced. These can easily be rubbed off with a finger, where they can be seen as a brown dust. Later in the season these pustules may turn darker with the production of resting spores (teliospores). The primary rust pustule may become surrounded by a ring of secondary pustules.

Lesions are predominantly formed on leaves, occasionally on pods and stems when the infection is severe, in which case defoliation may result.

Biology *U. appendiculatus* is an autoceious rust, i.e. it completes its life cycle on beans without requiring another host species. The teliospores serve as a resting stage, but, as bean plants are present in Kenya for most of the year, the fungus is generally able to survive without them. The reddish brown uredospores are the means of spread, usually by wind, but also on clothing and tools. Humidity in excess of 95% RH for several hours is required for infection, with the result that the disease reaches its greatest intensity in those areas of the country where the nights are damp and the days are dry and warm.

Control No bean varieties are resistant to all races of bean rust, but rust resistance is a very important criterion in selecting varieties for extension. GLP2, GLP 24 and GLP 1004 are tolerant to rust, whilst Monel and many French bean varieties are very susceptible.

The disease may be controlled chemically with sulphur or Maneb dusts or by spraying with dithiocarbamates, Bitertanol or Tridemorph, of which Bitertanol is the most effective. It should be noted, that chemical control is not recommended for dry beans. Excessive nitrogen fertilizer tends to increase infection whereas extra potassium reduces it, but neither of these have sufficient influence to recommend them as control measures.

Beanfly

Ophiomyia phaseoli (Try)

Symptoms The adult lays single eggs on the upper surface of the first primary leaves near the petiole. The site of oviposition appears as a sunken, light-coloured spot and the base of the attacked leaves has a characteristic speckling. Attacked leaves often turn yellow, giving the plant a droughted appearance. The maggots of the pest mine through the stem and the feeding activity of the late larval stages causes a characteristic swelling of the base of the stem at ground level. Numerous longitudinal cracks accompany the swelling. Infested plants often wither and die. Under heavy rainfall conditions, bean plants may

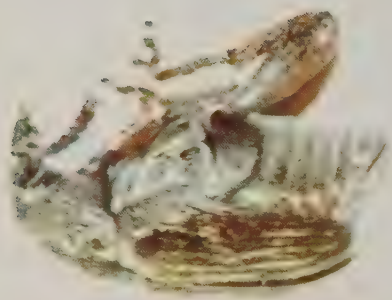
produce numerous adventitious roots above the swelling, which help the plant to survive. Sometimes older plants are also attacked, in which case maggots mine through the leaf blades and petioles, to the nodes where they feed. The nodes become necrotic, swollen and cracked and the plants start withering. Heavy infestation causes stunted growth and poor pod formation, but such old plants rarely die.

Biology Beans of various species are the main hosts but a wide range of leguminous species are also attacked. The eggs are slender, white in colour and about 1 mm long. The maggots are white and, on hatching, bore inside through the leaf blade, petiole and through the stem to just above ground level. Pupation occurs near the surface of the stem where the larvae have been feeding. The pupae are barrel-shaped, black or dark brown in colour and about 3mm long.

The adult is a tiny black fly about 3mm long. In general appearance the beanfly resembles a very small common housefly. The entire life cycle takes about 2-3 weeks.

Control All crop residues and volunteers should be removed after harvesting one crop and before sowing the next. In a given area all beans should be sown at the same time rather than successively.

Bean seeds may be dressed with Aldrin WP 40% (0.5 kg/100 kg) or crops may be sprayed with Dimethoate one week after sowing or Diazinon at the two true — leaf stage, and again a week later.



Bean Bruchid: Bean Weevil

Acanthoscelides obtectus (SAY). (Coleoptera: Bruchidae)

Symptoms: The infestation of beans by bruchids can start either in the field or in storage. In the former case there is very little physical evidence on the ripening pods to reveal the damage. In storage, infested beans, can be recognised by the presence of small circular holes all over the seed surface.

Biology: The main hosts are dry beans. Other pulse crops are alternative hosts. The adult female lays eggs usually in cracks on the ripening pods. The eggs are dirty white and

pointed. The eggs hatch in about 6 days and the larvae are tiny, dirty white or yellow in colour.

The mature larvae pupate in the seed. The adults, emerge and feed in the seed. When moving out of the seed, they leave a small circular hole about 2 mm in diameter. The entire life cycle takes about 4 - 6 weeks with the adult living for about 2 weeks, during which time the female lays about 40 - 60 eggs.

Control: Dry beans should be harvested immediately they are ready. Control of bruchids is as follows:

For Consumption:

a) The use of vegetable oils, such as sunflower oil (2ml oil/kg of beans), has been shown to keep the bean seeds free from infestation. This method is cheap, safe and easy to carry out.

b) The use of ground black pepper at the rate of 2.6g/kg of beans has been found to reduce infestation by as much as 78%. Higher doses of pepper have a correspondingly higher degree of efficiency, i.e. 11.1g/kg provides a 98% reduction.

c) Beans may be dusted with pyrethrum dusts or pyrimiphos-methyl.

d) For storage on a large scale beans can be fumigated with methyl bromide or carbon disulphide.

For Sowing:

a) Seeds may be treated with Aldrin at the rate of 70g/10kg to prevent infestation in storage. (ON NO ACCOUNT TO BE USED ON BEANS FOR CONSUMPTION).

b) Beans may be mixed with fireplace ash, thereby imposing a physical barrier.

c) Admixing with inert dusts such as crystalline silica, bentonite or magnesium carbonate effectively kills the insects.

Black Rot

Xanthomonas campestris (Pammel) Dowson

Symptoms The plant can be affected at any time during its life. On young seedlings a yellowing appears along the margin of the cotyledon, which later shrivels and drops off. On the margins of mature leaves, similar yellowing appears. Initially, a small V-shaped area develops, but, as the diseased area enlarges, the veins become distinctly black. (In Fusarium yellows the veins are brown). The affected stem, when cut crosswise, shows a characteristic black ring. In later stages the entire head turns black and soft, and soft rot bacteria may then enter and cause the head to rot and to develop an offensive odour.

Biology The source of inoculum is primarily through infected seeds, but, in subsequent crops, infested soil can be important. Under favourable conditions, the bacteria spread systematically in the xylem of succeptible plants up to the seeds, which are usually aborted. The bacteria exude to the surface of the leaf through stomata. Environmental conditions, such as high rainfall or high humidity, and high temperature (20-30° C) favour disease-development.

Control For a large grower hot water treatment of seed would be feasible (50° C for 30 minutes). As the disease is caused by bacteria, fungicidal seed dressing is ineffective, and whilst antibiotics have shown some benefit, they are not recommended in Kenya.

Where black rot is prevalent, farmers should try to practice a rotation based on at least a 2 year break in brassica crops on the infested land, coupled with removal of infected debris.

Cabbage Ring Spot

Mycosphaerella brassicola (Duby) Lindau

Symptoms All aerial parts of the plant are attacked, but usually older and lower foliage is most heavily affected and premature defoliation can result.On leaves, circular brown-grey spots up to 2 cm in diameter are observed; the spots consisting of a series of delimited, black-speckled, concentric zones. On the stems and leaf midribs, spots are oval or rectangular in shape. On stored cabbage this disease can penetrate deeply into the heart, thus requiring considerable trimming before sale.

Biology Although the chief sources of infection are crop debris and nearby infected crops, seedborne transmission

occurs. Most members of the cabbage family, including kale, cauliflower and Brussels sprouts, are susceptible. Disease development occurs at, or just below, 20°C but very high humidity is required for several days to permit spread.

Control It is usually possible to avoid much damage by this disease without resorting to fungicides. It is vital that infected leaves from earlier crops be removed and destroyed, and seedbeds should be sited away from mature plants to avoid very early infection of young plants. Where growth is rapid potash fertilizers reduce infection.

Fortnightly sprays with dithiocarbamates or Benomyl give good control but, because of the waxy surface of brassica leaves, a wetter should be added at four times the recommended dose.

Cabbage Aphids

Homoptera: Aphididae

There are three different species of Aphids which attack cabbage and other members of the cruciferae. Although control methods are the same, their appearance and host range differ and are therefore dealt with separately.

1) Cabbage Aphid

Brevicoryne bressicae (L.)

Symptoms These appear as masses of soft, pale green insects covered by a mealy powder. They feed in clusters on the underside of leaves and occasionally on stems. Infested leaves become yellow as a result of this feeding. If infestation

occurs on young seedlings they are stunted and distorted. Heavy infestation may even cause death of seedlings. Amongst the aphid colonies there are numerous white cast skins and drops of honeydew which act as substrate for the growth of sooty mould fungus.

Biology The insect is a major pest of cabbage but also attacks other members of the cruciferae.

The adults are all female, either winged or wingless and are covered by a grey, mealy, powdery wax which masks the green colour of the aphid. The adults produce living young. The aphid can transmit more than twenty virus diseases in the cruciferae.

Control Normally the population of the aphid is kept at very low levels by natural enemies, especially the predacious ladybird beetles and parasitic wasps. Occasionally, however, heavy outbreaks do occur, especially during dry weather, and application of insecticides becomes necessary.

Spraying wiht Dimethoate, Decamethrin or Oxydemeton-s-methyl will control the pest.

2) False Cabbage Aphid

*Lipaphis erysimi (*Kalt.)

This aphid is a minor pest of crucifers and is found mixed with colonies of the cabbage aphid. It is pale green in colour but is not covered with a mealy powder. Other names by which the aphid is known are "mustard aphid" and "turnip aphid".

Control See under cabbage aphid.

Green Peach Aphid, Peach-Potato Aphid, Tobbaco Aphid

Myzus persicae (Sulz-)

Symptoms This is a light green to yellowish green or reddish aphid which is polyphagous and widespread. It is important

in many crops and does damage by direct feeding, shown by distortion of the affected parts. It is particularly important as a vector of over 100 virus diseases of plants in about thirty different families.

Control Control of this aphid is especially important when there is an incidence of a virus disease. The roles of predators and parasites have to be considered if application of chemical insecticides is necessary. Care should be taken in avoiding close planting of several different susceptible crops.

Control - See under Cabbage Aphid.

Diamondback Moth

Plutella xylostella (L)

Symptoms The first larval instars behave like miners. They mine the lower epidermis leaving a transparent tissue of the upper epidermis. This is commonly referred to as "windowing". Later larval instars, normally three, feed right through the leaf blade, making more or less rounded holes. It is worth noting that the feeding activity is confined to the inter-veinal areas of the leaf blade, hence, under heavy infestation the leaves appear skeletonised, especialy when the holes merge. Early infestation in cabbages will result in failure of head formation, but normally developing heads are damaged by late attack.

Biology Brassicae of all species are attacked by the pest. Both cultivated and wild Cruciferae, however, are hosts. The whitish eggs are laid singly or in small batches on the upper surface of the leaf. The eggs hatch in 3-8 days, depending on temperature. The pale green caterpillar measures 12 mm when fully grown. When disturbed the caterpillars wriggle violently and drop off the leaf, remaining suspended by a silk

thread. Larval life takes 14 days under tropical conditions. The caterpillar normally pupates inside a net-like cocoon attached to the underside of the leaf. The green pupa is visible inside the cocoon. Pupal life is about 5-10 days.

The adult is a small grey moth measurng 7-8 mm in length. It has three triangular marks along the hind margin of each forewing, and when the wings are folded these marks form a diamond pattern, which gives the moth its common name. The female moth lives up to 20 days, laying 60-150 eggs.

Control Foliar sprays of Decamethrin, Fenthion or Carbaryl are effective.

Powdery Mildew

Leveillula taurica (Lev.) Arnaud.

Symptoms: Yellowish spots are seen on the leaves and a white, powdery deposit of spores can be seen on the undersurface of these spots. When severe infection occurs the leaves may dry up.

Occasionally, the white spore deposit can be seen on the petioles and some leaf shedding may occur.

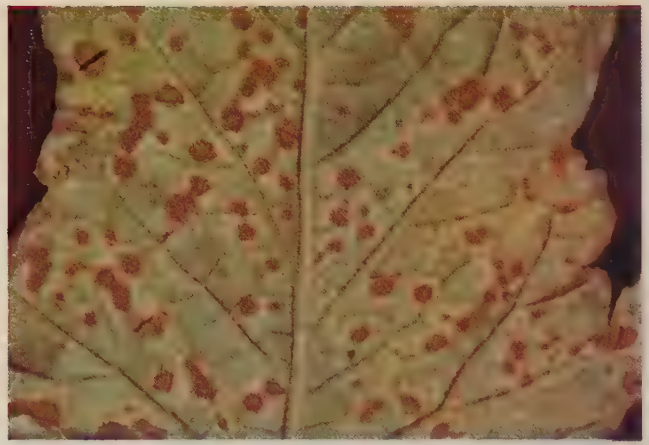
Biology The pathogen is unique in being the only species causing a powdery mildew which is endophytic, i.e. the mycelium of the fungus grows within the leaf. Other species of powdery mildew are superficial with penetration of the surface cells only.

It has an enormous host range, covering almost 60 families, and its biology varies, depending on the host attacked. It is not seed-borne but survives either on herbaceous weeds or on nearby crops of susceptible hosts.

The fungus can invade through the stomata or directly through the cuticle. Infection is favoured by temperatures slightly higher than 20°C and fairly high relative humidity, but dispersal takes place mainly at low humidities.

Control Because the disease is favoured by dry conditions and relatively high temperatures, it is reduced by sprinkle irrigation rather than furrow irrigation, as the former increases humidity and reduces temperature.

Sulphur dusts are effective but may scorch the foliage and fruit under hot and dry conditions. A wide range of other chemicals are available such as Benomyl, Tridemorph, or Dinocap, but this list is far from exhaustive.



Leaf Spot

Cercospora egenula (H. Syd.) Chupp & Doidge, and possibly other species

Symptoms Depending on the species of the pathogen involved, small regular or irregular brown spots are formed on the leaves, which often drop from the leaf as the tissue dies, leaving a "shot-hole" effect.

Biology Little is known about the factors responsible for this disease, but high humidity favours infection. Dispersal is by wind or splash. There is no record of the fungus being seedborne, so infection arises from debris or neighbouring plants.

Control Although this disease can be striking, it rarely yield to warrant control measures, apart from avoiding growing young plants near infected older plants. If it is felt necessary to apply fungicides, dithiocarbamates may be useful.

Leaf Spot

Cercospora unamunoi (syn. Phaeormularia capsiciola) (Vassil.) Deighton

Symptoms Circular or oval brown spots are formed on the leaves which, when numerous, cause the leaves to turn yellow and drop prematurely.

Biology The disease is particularly favoured by warm temperatures and high humidity. Although the disease can be seed-borne, debris is likely to be the most important inoculum source.

Control Compared with other diseases of capsicum, leaf spot is of minor importance, but may be controlled by dithiocarbamates fungicides or Captafol.

Anthracnose

Colletotrichum capsici (Syd.) Butler & Bisley

Symptoms Typically this disease affects ripe fruit by producing grey-brown sunken spots on the fruit which, in damp weather, become covered with a salmon-pink mass of spores. The disease also sometimes affects the fruit stalks and twigs.

Biology The disease is seed-borne; but this aspect is generally unimportant except in spread of the disease to new areas. Infection is more likely to arise from debris or old fruits. The disease is encouraged by high temperatures and humidity and is normally dispersed by splash.

Control Fruits showing anthracnose lesions should be immediately destroyed to prevent further infection. As the disease is splash dispersed furrow irrigation is preferable to sprinklers. If necessary, dithiocarbamate sprays may be applied, but care should be taken, as this is a disease of ripe fruits, that safety intervals between sprays and harvest must be strictly observed. For most dithiocarbamates the safety interval is at least one week.

Mosaic

Potato Virus Y (PVY)

Symptoms The plants are stunted with leaves distorted, individual leaves showing irregular dark green vein banding. There may be some chlorosis between the veins. Infected plants do not recover from the disease, i.e. the plant does not "grow away" from the infection. California Wonder is a particularly susceptible variety, showing severe symptoms. The disease affects most capsicum crops in Kenya.

Biology This virus is transmitted by aphids, primarily *Myzus persicae* and *Macrosiphum euphorbiae.* It is essentially identical to Potato Virus Y on potatoes, except that potato isolates cause only mild symptoms on capsicums and

isolates causing severe damage on capsicums cause only mild symptoms on potatoes. A strain of the virus, possibly identical to that on capsicums, causes a green mosaic on tomato leaves and deeper coloured blotches on the fruit. The disease is not seed-borne in capsicums or tree tomatoes.

Control Capsicums should be maintained free from aphids by the use of insecticides (see Brassica - cabbage aphids) and if a small proportion of plants are infected, these should be rogued.

Powdery Mildew

Leveillula taurica (Lev.) Arnaud.

Symptoms This is the same disease and pathogen as occurs on brinjals and symptoms are similar, except that on capsicums leaf drop is more pronounced.

Biology Similar to that on brinjals, except that disease development is greatest at 25°C.

Control As for brinjals.

Alternaria Blight

Alternaria dianthi Stevens & Hall

Symptoms Stems, leaves and occasionally flowers are attacked by this disease. Lesions on either leaf surface are first seen as tiny, purple spots which develop into light brown necrotic spots with a chlorotic border. As time passes, the spots enlarge with the necrotic area becoming proportionately larger than the chlorotic halo and the centre may become dark brown to black due to sporulation of the fungus. If lesions coalesce, the entire leaf may be killed.

Stem lesions are usually first seen on one side of the node, but may eventually girdle the stem. The lesion is sharply defined from the healthy tissue and has the appearance of a

dry, brown rot. Branches and leaves arising from the node eventually become completely dry and straw coloured.

A further symptom which may be noticed arising from the stem lesions is a mottling of the leaves, and care should be taken to avoid confusion with virus diseases. Mottled leaves generally turn yellow, wilt and die.

Biology Although the disease can be seed-borne, this is of little importance in commercial plantings, as these are raised from cuttings rather than seed. Development of the disease occurs over a wide range of temperatures, but spread occurs during periods of high humidity, due to the spore production. Spread is by wind or particularly by splash.

Control Care should be taken to select disease-free cuttings, preferably taken midway up the stem. Removal and burning of infected branches should be done where possible. Where the plants are grown under polythene it is possible to almost eliminate the disease. Surface watering is preferable to the use of sprinklers.

Chemical control should be started before the disease becomes established and sprays should be repeated every 7-10 days, starting soon after transplanting. The entire foliage should be covered. Chemicals of choice include Daconil, Captan, Zineb or Rovral.

Fusarium Wilt

Fusarium oxysporum f. sp. *dianthi*
(Prill. & Del) Snyder & Hansen

Symptoms Plants may show symptoms at any stage of development. The first indication of Fusarium wilt is a slow withering of the shoots, often apparently on only one side of the plant. In young plants this results in distortion because the plant tends to curl to one side. Yellowing and wilting of the lower leaves ensue, and stem internodes at the base of the plant show a browning or yellowing on the affected side. As the disease progresses, the symptoms spread up the affected branch, leaving only a tuft of green leaves at the tip, the remainder of the leaves being yellow and wilted. When

the shoots are cut lengthwise, vascular discolouration can be seen as streaks which often extend from the roots to the uppermost parts of the stem. The fungus often causes abnormal growth and stunting of the shoots.

Biology The fungus persists in soil for long periods and is spread by contaminated soil, pruning tools and infected cuttings. Symptoms develop most rapidly and become severe at high temperatures. At least three races of this fungus occur, but no information exists on the races present in Kenya. *Lychnis calacedonica* (Maltese cross) is a further host in the same family.

Control Crop hygiene is the most important control method for this most serious disease of carnations. Disease-free mother blocks should be maintained to provide a supply of healthy cuttings. Soil for the propagation beds can be sterilized with Vapan or Dazomet. As infection can take place through wounds, care should be taken during field operations to avoid mechanical damage. Benomyl and Thiophanate methyl are effective as soil drench and Captan sprays (weekly) are reported to give control. Some varieties are resistant to particular races but this could change if other races become prevalent.

Rust

Uromyces dianthi (Pers.) Niessl (Syn. U. *caryophillinis*)

Symptoms This is a disease primarily of standard carnations and the symptoms are typical of other rusts, being small, chocolate brown blisters or pustules breaking through the leaf and stem surface. Individual leaves may be killed or the entire plant may be weakened and stunted.

Biology This is one of the rusts which may have an alternate host in its life cycle, but it is not known if the alternate hosts, species of *Euphorbia,* are required for completion in Kenya. If carnation material is available continuously to the fungus, then it can carry on infecting this material without the

alternate host being involved. It is favoured by moist conditions and requires free water for germination of spores.

Control Wherever possible, the foliage should be kept dry by the use of surface watering rather than sprinklers. As conditions in the propagation bed favour infection, the use of already infected cuttings should be avoided, otherwise rapid spread could result. In cases where rust is expected to be severe it can be controlled by weekly sprays of Oxycarboxin, Zineb, Polyram Combi or Captan. When liquid feed systems are used Oxycarboxin can be incorporated in the nutrient solutions immediately after planting.

Alternaria Blight

Alternaria dauci (Kuhn) Groves & Skolko

Symptoms Infected leaves exhibit elongated lesions which are irregular in shape and lack a definite margin. Older leaves are usually infected, causing single leaflets to collapse and die. Attack is late in the crop and there is, consequently, little effect on yield.

Biology Infected debris on the soil surface, and seed are important inoculum sources. Dry weather favours the survival of the organism in the infected crop debris, whilst wet weather often stimulates epidemics.

Control Although the disease is rarely important due to its

late development it may be advisable to treat seeds with a fungicide where this has not already been done before sale. Soaking in Thiram for 24 hours at 30° C is effective. Should conditions cause infection to appear earlier than normal, a dithiocarbamate, e.g. Thiram or Zineb, could be used.

The removal of infected foliage or deep cultivation to bury the debris is also recommended.

Cashew Helopeltis

Helopeltis anacardii Miller

Symptoms Both vegetative and flowering shoots are attacked. The affected leaves show, particularly along the veins, dark angular lesions which are sometimes accompanied by exudation of gum. The attacked tender shoots die back, probably in association with secondary infection by fungi. The damage is caused by the injection of toxic saliva. In case of serious infestation the trees appear scorched. Growth of such trees is heavily retarded and fruit formation reduced. Death of the terminal bud stimulate growth of auxiliary buds, giving a witches broom appearance. The pest also feeds on the developing apples and nuts, which

shrivel and dry up, if attacked when young, they show pock-like marks and a reduction in size if attacked at a later stage.

Biology A complete life cycle takes about 4-10 weeks. Breeding of the bugs is continuous. The white eggs measure 1.5-2.0 mm in length, are test-tube shaped, slightly curved with a marked cap and have two unequal hair-like filaments at one end. They are normally laid embedded in the soft green tissues near the tips of flowering or vegetative shoots. The nymphs, slender and about 7 mm long, are red or yellow with long antennae. The adults generally resemble the mature nymphs, but are more orange-brown and are larger (males 4.5 mm; females 6.0mm) with transparent wings extending beyond the tip of the abdomen. Adults may live 2-3 weeks. All stages of the bugs avoid direct sunlight. The population normally builds up during the rainy season, particularly during the July-December period, when the trees are in their most active growth.

Many other crops and weeds may be attacked by the pest.

Control Cashew seedlings in the nursery should not be shaded.

Chemical control can be obtained by spraying with Phosphamidon, Fenitrothion, Fenthion, Carbaryl or Trichlorphon at 2-4 weekly intervals.

Greening Disease

Associated with a bacterium

Symptoms All the above ground parts of a diseased tree show symptoms. The leaves may show mottling, yellowing of veins or zinc deficiency symptoms, i.e. small leaves, interveinal chlorosis and brush-like growth. Zinc deficiency induced by greening is confined to one or several branches within a tree (sectoral infection) and trees with the symptoms are irregularly distributed within an orchard. Affected branches bear few, if any, fruit. The affected fruits are usually under-developed, lopsided, start to colour from the peduncle end instead of the stylar end as is the case with healthy fruits, and they drop prematurely. In seedy varieties,

seed abortion occurs. Severely diseased trees exhibit open growth, sparse, chlorotic foliage, die-back of branches and severe fruit drop.

Biology The disease is spread by psyllid *(Trioza erytrae* q.v.) and by man through the use of budwood from diseased trees. It is not soilborne, and it is neither seedborne nor mechanically transmissable. The disease is especially destructive in sweet orange and mandarin, and it is less severe on lemon, grapefruit, citron and West Indian lime. Greening-susceptible species are affected on all rootstocks. Because of the sensitivity to high temperature of the casual organism and the psyllid, the disease is not found below about 800 m in Kenya.

Control Budwood should only be taken from vigorous growing, high producing, healthy trees. Always take budwood from greening-free areas (e.g. Coast, Garissa) but if the budwood source is from the highland areas (above 800 m altitude), the budsticks should be treated by dipping in a solutin of tetracycline hydrochloride (1000 ppm) for a period of 2 hours. Strict control of psyllids with systematic insecticides (e.g. Dimethoate, Oxydemeton methyl, Fenetrothion, etc.) must be practised in nurseries and orchards located in highland areas. Partially infected trees can be treated by injection with tetracycline hydrochloride (6 - 10 gm/2 litres/tree). Tree injection with the antibiotic causes remission of leaf symptoms and production of healthy fruits. The treatment interval is about 2 years. Very severely infected trees not producing marketable fruit of economical yield should be uprooted, although, if only a few branches are affected in an orchard, they can be pruned out. Young trees showing generalised symptoms should be replaced as they will never bear fruit.

Gummosis

Phytophthora spp.

Symptoms On trees budded on rough lemon rootstock the disease is usually seen just above the bud union, starting as a patch of water-soaked spots which rapidly start to exude gum. The bark in such areas remains firm but later dries and cracks to form a gum filled canker. The bark beyond the killed area often shows a yellow staining when outer layers are peeled off. Feeder roots may also be destroyed, and, on seedling trees, the gumming lesion on the trunk may extend some way below the ground.

The effect on the tree is one of starvation of the aerial parts with a general decline in vigour, shown by leaves and fruits of reduced size.

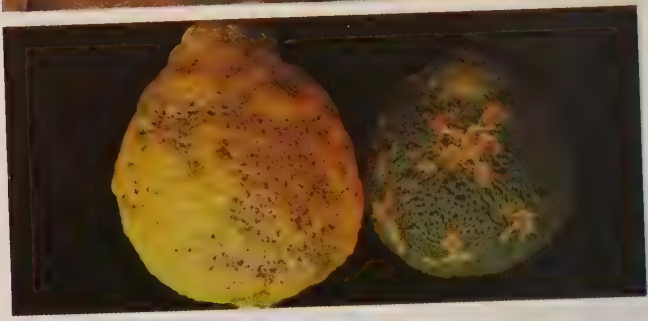
Biology Three species of *Phytophthora* can cause gummosis in citrus but it is not known which species is most common in Kenya. Although two of the species also cause brown rot of citrus fruits and can infect the seed, in practice the disease must be regarded as soil-borne. Lemons are the most susceptible citrus species, with sweet orange, lime, rough lemon and grapefruit being increasingly resistant, in that order. Sour orange is resistant and its use as a rootstock prevents gummosis, but the risk and damage due to Tristeza (q.v.) are greater and it is therefore avoided. In many circumstances in Kenya rough lemon gives adequate protection; indeed, its partial resistance to gummosis is one reason for the use of a rootstock. Sweet orange seedling trees are vulnerable.

Gummosis usually attacks the scion when soil comes into contact with it, such as when the grafted tree is planted too low. The same effect occurs when a tree is planted in a basin which may be flooded during irrigation, allowing the fungus to reach the scion. In general the disease is encouraged by excessive soil moisture and poor drainage.

Control When selecting trees for planting, only those budded at least 20 cm from the ground should be chosen and care taken to avoid planting too deep. The graft union should be at least 15 cm above ground after settling of the soil.

If trunk lesions do appear on older trees the affected areas may be cut away, removing also a 2 cm margin of healthy bark. The wound can then be painted with a slurry of metalaxyl, with a further spray after a month, or foliar sprays of phosethyl - aluminium, which acts over a longer period, thus reducing the number of sprays.

Affected orchards should not be excessively irrigated.



Scab

Elsinoe fawcettii Jenkins

Symptoms It is most severe on sour orange, lemon, rough lemon, Temple sweet orange and some tangelos (e.g. Minneola). Of these rough lemon is most widely grown because of its preponderent use as a rootstock in the country.

It is therefore mainly of importance in citrus nurseries, where infected rootstock seedlings may become stunted when infection is severe. On very young leaves the first sign of infection is the formation of circular protuberances, usually on the underside of the leaf. These protuberances gradually darken from a cream colour to buff as they become more corky, and depressions become visible on the upper

surface. When severe, these lesions may cause the leaf to distort and fall prematurely. This distortion of the tender apical leaves causes a stunted, bushy growth. The young succulent twigs may develop similar lesions, contributing to the general bushiness of the seedling.

Fruit infection consists of irregular, slightly raised wart-like growths, occasionally resulting in premature fruit drop. The colour of the "scabs" ranges from buff to olive-drab.

Biology The spores of the fungus live from season to season on infected leaves and, to a lesser extent, on infected fruits. Water, in the form of rain or irrigation or heavy dews, in necessary for both dissemination and infection. The optimum temperture range for both spore production and infection is very wide with the result that infection can occur in most areas of Kenya, irrespective of the season, provided young tissue is available.

Control The importance of the disease is essentially the damage caused in the nursery. The resulting stunted, bushy rough lemon seedlings are difficult to bud and the rootstock lacks vigour. In the nursery, chemical control can be achieved by two-weekly applications of neutral copper (e.g. copper oxychloride) or tri-weekly applications of Zineb.

Susceptible rough lemon trees should not be grown in an orchard close to the slightly less susceptible varieties with marketable fruits such as grapefruit and lemons. To control the disease on fruits of such trees, two sprays are recommended, one just before the growth flush starts, and then again when two thirds of the blossom petals have fallen of. Copper oxychloride or Zineb are the fungicides of choice, although Benomyl has been reported to be effective as a single spray. Infected water shoots of rough lemon should be removed.

Tristeza

Virus (localised in phloem tissues)

Symptoms Symptoms of Tristeza lack specificity and are similar to those of trees in which roots have been injured or killed (e.g. trunk girdling, water damage, nematodes, fungi, etc.). Leaves exhibit bronzing and various deficiency symptoms; foliage wilts, leaves drop, and twigs, branches and roots die back. Diseased trees have an unthrifty appearance and are commercially unproductive. During periods of low humidity the leaves may rapidly wilt and dry on the trees (Quick Decline). Particularly susceptible citrus species (Mexican limes and grapefruits) exhibit pitting or channeling of the wood under the bark and the young

leaves show vein clearing (a narrow, faint chlorotic emargination of the veins). When 2.5 cm squares of bark across the bud union are removed, a massing of many fine holes or pitting (honeycombing) is apparent in the rootstock just below the bud union.

Biology Tristeza is specifically a disease of sweet orange on sour orange rootstock. Strains of the virus, however, have been reported to attack sweet orange on rootstocks other than sour orange. This is the case in Kenya, where the disease is prevalent in all citrus growing areas (endemic) though the standard rootstock is the rough lemon. Rootstock varieties generally considered tolerant to tristeza virus are sweet orange, Cleopatra mandarin, rough lemon, Rangpur lime and trifoliate orange. The virus is spread in the field by aphids (Toxoptera *citricidus, T. aurantii, Aphis gossypii, A. craccivora, A. spiraecola* and *Myzus persicae)* and by use of budwood from diseased trees.

Control A practical safeguard against Tristeza is to use only disease-free budwood and to ensure that they are budded on the tolerant rootstocks, whilst aphid vectors can be controlled by systemic insecticides. There is, however, little chance of accomplishing more than a slowing down in the rate of spread. In Brazil, where Tristeza has been the major problem of citrus, its control has been achieved by use of budlines pre-immunised with mild strains of the virus to protect against severe strains.

Citrus Nematode

Tylenchulus semipenetrans Cobb

Symptoms Above ground symptoms may not be noticeable until 5 to 10 years after the peak of the nematode population is reached. When symptoms finally appear they consist of yellowing of leaves and general symptoms of malnutrition, such as sparse foliage, small, non-uniform fruits, and die-back. Infested trees tend to shed fruit more than normal; this is particularly noticeable during stress periods such as drought or high temperatures.

When roots are examined they appear somewhat enlarged and have a very irregular, rough surface, irrespective of adhering soil. The nematode does not cause galling or knotting, but the females exude a gelatinous matrix to protect the eggs, and soil particles adhere to this.

The degree of decline may vary from tree to tree and there is a negative correlation between the degree of decline and nematode numbers in the soil. This is because nematode numbers decrease as the roots decay, with the result that nematode numbers may be less on a severely declining tree than on an apparently healthy tree where there are many roots on which the nematodes can feed.

Under optimum conditions of cultivation, trees can live and produce normally in spite of the presence of the nematodes, but eventually the trees decline, with a reduction in yield and quality.

Biology The life cycle takes 6-8 weeks at 25°C. Eggs are laid on the roots in a gelatinous matrix, from which the larvae emerge after 12-14 days. Both male and female larvae moult a few times before reaching maturity, but only the female feeds on, and infests roots by embedding itself in the cortical cells.

Control Only healthy seedlings free from nematodes should be planted, so as to avoid infesting new ground. Trees

planted in infested soil, however, become damaged and often show symptoms earlier than do infested trees planted in non-infested soil.

Where it is known that an orchard site is infested, preplant fumigation with D-D (dichloropropane-dichlorpropene) or EDB (Ethylene dibromide) is effective. Alternatively Carbofuran or Phenamiphos may be applied to the soil around trees to control existing infestations.

Citrus Aphid
Toxoptera aurantii (B.d.F.) &
Toxoptera citricidus (Kirk)

Symptoms Dense populations of aphids are found on the leaf surface during flushing and, as a result of their sap-sucking, leaves are curled and distorted. The insects are also found on the stem of young shoots which may die back. Flower buds are damaged or drop and leaves and fruits may be turned black by Sooty Mould growth on the honeydew secreted by the aphids. Symptoms can be severe on flush growth during dry periods following a rainy season.

Winged adults of *T. citridicus* transmit Tristeza (q.v.) and other virus diseases. The aphid colonies on the young shoots consist mainly of wingless nymphs and adults. The adult of *T. aurantii* is darker than the adult of *T. citricidus* which is brown - black. The nymphs of both species are brown, The colonies are usually attended by ants which feed on the honeydew.

Biology Citrus aphids are mainly found on orange and lime, but all citrus species can be attacked. Alternatively *T. aurantii* is found on a wide range of plants, including coffee, tea, mango, Annona, Macadamia, *Ficus* spp., *Hibiscus* spp., *Eugenia* spp., etc.

The adult aphid, black or brown in colour, may be winged

or wingless (apterous). Both forms produce living young (nymphs), but wingless adults produce more offspring: they produce over 50 nymphs. No male forms have been observed. The females reproduce female offspring without fertilization. Temperatures around 25° C favour rapid development of the life cycle, which can be completed in only 6 days. Very high tempertures (around 30° C) are unfavourable for *T. aurantii,* but *T, citricidus* can tolerate higher temperatures. Neither species thrives at temperatures below 20° C.

As infested leaves harden, more winged forms appear, looking for fresh flush.

Ladybird beetles and Hoverflies are important predators of aphids. Both larvae and adults of Ladybirds feed on aphids; with Hoverflies, only the slug-like larva eats aphids. Aphids are also attacked by at least 3 different species of parasitic wasps which cause them to mummify, change colour and become more rounded. On emergence, the tiny wasps leave a round hole in the mummy skin.

Control Normally ants protect aphids against natural enemies. If ants are kept off, predators and parasites will be more effectve. Ants can be stopped by tying a Dieldrin-saturated cloth around the stems of trees. (GLOVES MUST BE USED)

Direct chemical control measures should be taken as soon as the first aphids are observed on the flush. Spraying should be directed towards infested shoots with special emphasis on the underside of the leaves. When citrus plants are checked regularly only infested plants or sprouts should be sprayed. Recommended insecticides are: Dimethoate, Oxydemeton-methyl or Fenitrothion. Alternatively, Malathion, Diazinon or Endosulfan can be used.

Orchard trees can be protected for 6 weeks by using soil drenching of Dimethoate at the start of flush growth, (see under Control of Citrus Psyllid).

Citrus Black Fly

Aleurocanthus woglumi Ashby

Symptoms Colonies of black, scale-like insects are found on the underside of leaves. As a result of sooty mould growth on the secreted honeydew, foliage, twigs and fruits may turn black.

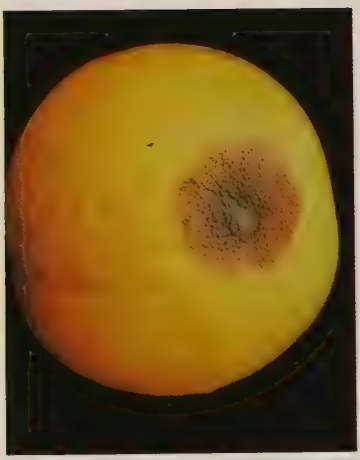
Biology Citrus species are the most important host plants, but there are other cultivated plants such as guava, mango, *Annona*, cashew and coffee, which may serve as alternative hosts. The eggs, about 0.2 mm long, are usually laid in a spiral on the lower leaf surface and they are fixed to the leaf with a short thread. There are 4 larval (nymphal) instars which look like black scale insects; they bear black "hairs"

and they are surrounded by a white fringe of wax. The length of the nymphal period depends on temperature and humidity. In hot, humid weather it may take only 5 days. Population levels are highest during the wet season. The adult resembles a tiny greyish moth, about 1 mm in length. When disturbed it makes only short flights. Above 3000 feet above sea level Black Fly occurence and damage are low.

In several countries parasitic wasps have been introduced which successfully controlled the Black Fly. A survey in the coastal areas of Kenya (1958) did not reveal any parasite, but it did show that Ladybird beetles provided some control of the Black Fly. In other countries *Crysopa* sp.*(Neuroptera)* and pathogenic fungi are reported as natural enemies. In 1959 the parasite *Eretmocerus serius* was released at the coast in Kenya and, for many years afterwards, Black Fly was not a problem. Recently, however, this little wasp was found to be no longer effective in controlling this pest.

In 1966 another wasp, named *Prospaltella opulenta* was imported and released at Kibos, near Kisumu, where it has established itself.

Control In case biological control is insufficient, careful spraying of infested trees with dimethoate is recommended. Spraying should be directed to the lower leaf surface. Other effective chemicals include Diazinon, Malathion and Permethrin. Plant material from affected sources for new citrus plantations should be completely defoliated and the branches should be dipped in a dimethoate solution before planting.



False Codling Moth

Cryptophlebia leucotreta Meyrick

Symptoms The initial symptom on the fruit is a more or less circular spot with a tiny dark centre where the insect entered the fruit. At a later stage the affected spot often, but not always turns brown and expands. An infested fruit yellows prematurely. Opening the fruit will show a white or pink caterpillar boring in the pulp, leaving granular frass. Sometimes the caterpillars enter the seeds, hollowing them out.

Fungus easily infects the fruit at the affected spot, but usually this infection does not extend beyond the area where the insect has been feeding. The conspicuous brown patch on the fruit skin normally hardens. Some other host fruits like castor or avocado may show granular frass coming from the infested spot. Affected cotton bolls often develop a soft rot.

Biology Fruits of many different plants are attacked, such as citrus, cotton, okra, maize, simsim, macadamia, pomegranate, guava, avocado, castor bean, wild figs etc. Usually no more than 1 or 2 false codling moths develop from each citrus fruit, but from one pomegranate fruit 5 moths may emerge. The moth is found all over Kenya and is apparently adapted to various climatic conditions.

The adult moth has a wingspan of about 1.6 cm and is brownish in colour. It flies only at night.

After ovipositing on citrus fruits, sponge-like eggs can be found in some of the numerous depressions of the fruit skin.

The hatched larvae, white and spotted, penetrate the fruit and later become pink or red in colour. In citrus pupation usually takes place in the soil, after the fully grown caterpillar, often over 1.5 cm long, has left the fallen fruit. Sometimes pupation occurs inside the fruit.

The pupal cocoon is normally made from silk and soil particles. The emerging brown moth needs at least three days for maturing and ovipositing. The life cycle takes between 35 and 60 days depending on weather conditions.

Natural enemies apparently have a very small role in the control of the pest - except during prepupation and pre-emergence periods.

Control Twice a week fallen fruits as well as infested fruits still on the tree should be removed. To prevent emergence of the moth from these fruits they can be buried (50 cm deep) or dumped into drums filled with water into which a little old oil has been added. The fruits should be left in the drum for at least one week. When buried less than 50 cm deep, the covering soil should be treated weekly with insecticide, such as Phosphamidon or Fenthion, for 5 weeks. The spraying of trees with insecticides for chemical control of the false codling moth is not satisfactory.

It is advisable to remove wild castor ("Mbarika") around the orchard, since this plant serves as an alternative host.

Fruit Flies

Ceratitis capitata Wied. & *Ceratitis rosa* Karsch

Symptoms Spots develop on the fruit skin where eggs were laid and the hatching larvae enter the fruit. On immature fruits the spots are yellow or brownish, but on older fruits soft rotting follows. Several small, white maggots (fly larvae) are found boring in the rotting pulp. Attacked fruits rot and usually drop prematurely. Fruit fly infested fruits can be distinguished from those infested by false codling moth by their rotting; fruits affected by false codling moth do not necessarily rot.

Sometimes fruits are punctured by the female fly, but no eggs are deposited. In this case the fruit may still rot and

either stay on the tree or fall onto the ground. Rotting fruits can be infested by secondary insect pests, such as dried fruit bettle and *Zapriounus* flies.

Yield losses of at least 20% have been reported in some Kenya orchards.

Biology There is a wide range of flies attacking fruits, including genera such as *Dacus* (e.g. Melon Fly), *Drosophila, Zapriounus* and *Ceratitis. Ceratitis* is the most important genus, with the most important species being the Mediterranean Fruit fly (*C. capitata*) and the Natal Fruit fly (*C. rosa*). The latter is a little bigger than the former, has greenish eyes and has less white markings on the back. The former has blueish eyes. Both species are similar in overall appearance and behaviour. Their wings show yellow and brown markings and are always kept spread. The flies are 4 - 7 mm long.

In Kenya *C. capitata* is much more common than *C. rosa.* Both species attack fruits other than citrus, e.g. for *C. capitata* 253 different fruits and vegetables throughout the world have been recorded as host, peach apparently being the most favoured. In Kenya the Mediterranean Fruitfly is most often found on orange, although it also breeds on grapefruit and even on rough lemon; the Natal Fruit fly is more common on grapefruit than the Mediterranean Fruit fly.

The adult female lays eggs within the skin of ripening fruits, and this puncture often leads to rotting. The hatching larvae burrow further into the fruit, feeding on the rotting pulp. When the infested fruits fall the larvae emerge and pupate in the soil. After the fruit has fallen it may take up to 45 days for the adult fly to emerge, and a further 8 days at 28° C for the female to reach sexual maturity. At this time they feed on sugars such as the honeydew produced by aphids or scales.

Coffee is one of the most important host plants in Kenya though its berries are not damaged by the pest. Population peaks occur around July/August and November to January.

Control Six different parasitic wasps have been recorded as natural enemies of the Med. Fruit fly in Kenya, but their importance seems limited. Probably more important are ants and other soil insects which attack mature larvae leaving the fruits, pupae in the soil or the newly emerging flies.

All fallen fruits and affected fruits still on the tree should be removed and destroyed (see False Codling Moth) twice a week. After the end of the picking season no fruit should remain on the ground or on the tree. Bait sprays containing Protein hydrolyzate (e.g. "Buminal") or sugar (molasses) can be very effective when mixed with Malathion, Trichlorphon or Fenitrothion. Alternatively Fenthion can be sprayed without bait. To attract and kill flies the bait spray should be applied in large drops. Bait spray application on every second or third tree is sufficient, and only part of the foliage needs to be covered. There should be 150 - 500 ml of bait spray solution per tree, depending on tree size. Any spraying should start just before fruits turn yellow or start ripening and the spray should be repeated 10 days later. No sprays should be applied within 14 days of picking.

Orange Dog

Papilio demodocus Esp.

Symptoms The caterpillars, white/brown or green in colour, feed on the edges of both young and older leaves. Damage can be severe, particularly on young trees which can be defoliated.

Biology Various *Citrus* species, *Teclea nobilis* (Rutaceae) and Cape Chestnut are host plants. The adult, yellow/brown butterfly is common during rainy seasons and lays single white/grey eggs mainly on the underside of young leaves. After hatching there are 5 or 6 larval stages. When they are young the caterpillars resemble white and brown bird droppings. Later they turn green with some black, brown and

grey. If disturbed they show a bright, yellow/orange, Y - shaped organ from behind the head, which produces a strong smell and has given the caterpillar its name, "Orange Dog". The fully grown caterpillar is about 5 cm in length. The total larval period takes about 1 month. The brown pupa is found attached to the twig and it takes about 2 weeks before the adult butterfly emerges.

There are some small wasps attacking the Orange Dog caterpillar and there is also a parasitizing fly. In addition, several birds feed on the Orange Dog.

Control On small trees hand-picking of the caterpillars usually provides sufficient control, provided the citrus plants are checked regularly. When greyish single eggs are found, they should be destroyed too. Severe outbreaks or big trees may need spray application of Malathion, Fenthion or Fenitrothion.

Citrus Psyllid

Trioza erytreae Del G.

Symptoms Bump-like galls are found on the upper leaf surface as a result of the sucking activities of the yellow, scale-like psyllid nymphs on the underside of young citrus leaves. The diameter of the galls is about 2 - 3 mm. Heavy psyllid infestation may cause severe leaf distortion, which is sometimes accompanied by leaf yellowing. After emergence of the adult insects, the affected leaf will harden and normally regain its green colour, but the bumps remain.

Biology The Citrus Psyllid seems to be confined to the Rutaceae family, including all citrus species and the wild tree *Clausena anisata* (Kikuyu: Mutathia). The Citrus Psyllid is

only found at altitudes above 800 m, with cool climates; it is not observed at the coast or in hot,dry regions like Garissa.

Rough lemon trees, in particular where they flush frequently, seem to be very suitable for the insect.

T. erytreae is the vector of greening disease of citrus.

The life history of the Psyllid, which breeds exclusively on young foliage, consists of an egg stage, 5 nymphal stages and a winged adult. Emergence of adults tends to synchronize with the citrus growth cycles. The pre-oviposition period lasts 3 - 5 days at 25° C, but is longer when colder or in the absence of young growth.

Tiny yellow eggs are laid on the edges and main veins of tender young leaves. The eggs hatch after 5 - 10 days. The first nymphal stage is mobile and these feed on the lower leaf surface. Once the yellow nymph has settled it becomes sessile. These nymphs resembling flat scale insects, are about 1 mm long, oval in shape, with yellow bodies and 2 red eyes. They lie in the cup-shaped galls produced on the infested leaf.

Parasitized nymphs usually become dark brown. The adult psyllid is an aphid - like insect, 2 - 3 mm in length and with long, conspicuous wings. When still young, the adult is yellow-green but becomes brown later.

The period from egg to adult is 18 - 42 days, depending on environmental conditions. Temperature and humidity are of vital importance to the vulnerable eggs and first nymphal stage, high temperature (over 25° C) together with low humidity are lethal to the young insect. Among other factors affecting psyllid populations are availability of flush leaves and parasitism by wasps. Prolonged flushing as induced by Greening disease, favours psyllids. Dry and hot conditions during periods with low flush density result in a major psyllid decline.

Natural enemies are mainly small, parasitic wasps (*Tetrastichus dryi, Aphidencyrtus* spp.) attacking the older nymphal stage. These wasps are usually of little importance

at the start of major flushing time in August, but later may kill 75 - 100% of the nymphs, drastically reducing the psyllid population. Some of the parasites can also be found attacking related psyllid species on wild fig trees.

Control Chemical control methods are only necessary during periods of heavy flush. In nurseries a spray mixture of 4 ml dimethoate 40% and 26 ml of White Mineral Oil per 10 litre of water is recommended. Higher concentrations of Dimethoate are harmful to non-budded rough lemon plants. Other effective insecticides include Oxydemeton methyl, Malathion, Diazinon, Fenitrothion or Endosulfan. Sprays should be directed towards the lower leaf surface and be reeated every 7 - 10 days, as long as young leaves appear.

For orchard trees a soil drench with Dimethoate is effective. For every square metre of shade area, 10 ml of the concentrate diluted with some water should be poured onto the soil under the tree. This method should be effective for 6 weeks, but cannot be used on rough lemon trees. Alternatively, sprays may be applied, but then the treatment must be repeated every 7 - 10 days during the flushing period.

Scales

Symptoms Scale insects, of which there are many species occurring in many different forms, appear to be "fixed" on the plant and are often accompanied by ants. Damage is caused by sap sucking, mainly on leaves and branches, resulting in discolouration of foliage, poor growth and branch die-back. The presence of scales is often accompanied by sooty mould growth, turning affected plant parts black. Some scales are found on fruits, which lowers the market value. Frequent usage of wrong pesticides and incorrect timing of application often induce scale attacks.

Biology There are two main groups of scale insects, namely Soft, or Naked, and Hard, or armoured, Scales. Closely related to these groups are Mealy Bugs and Cottony Cushion Scales.

With Soft Scales the covering "scale" is firmly fixed to the

insect skin. They produce much honeydew attracting ants and providing a suitable substrate for sooty mould growth. Soft Scales include White waxy Scales, Soft Green Scales and Soft Brown Scales.

With Hard Scales the hard "scale" is not attached to the insect skin. Here the adult scale cover also includes the scales of the young nymphs. They produce little or no honeydew. Hard Scales include California Red Scale, Florida Red Scale, Citrus Snow Scale and Citrus Mussel Scale.

Soft Green Scales *(Coccus viridis Green & Coccus alpinus* De Lotto)

These scales are flat and oval in shape and green to pale green. They are therefore inconspicuous on leaves and often only seen after the appearance of ants. *C. viridis* is mainly found at low altitudes (e.g. at the Coast). Mature scales are 2-3 mm. They are comparatively easy to control with insecticides.

Soft Brown Scale *(Coccus hesperidus L)*

C. hesperidus, apart from its brown colour, closely resembles the Soft Green Scale. It is also found on papaya, cotton and ornamental plants and is also attended by ants.

Waxy White Scales *(Gascardia destructor* Newst. & *G. brevicauda* Hall)

Both species have only one generation per year. The adults are covered with a white waxy "cream", which in *G. brevicauda* show distinct white lines which are lacking in *G. destructor.* Beneath the white wax is a reddish or brown scale, which is conical in shape in *G. brevicauda* and dome-shaped in *G. destructor.* Only the first larval instar is found on the leaves, the older stages moving back to the twigs. Heavily infested branches can be cut off and left on the ground for possible parasites to survive. Chemical control should be carried out during the *first* larval stage only (found on leaves); sprays have little or no effect on the older insects.

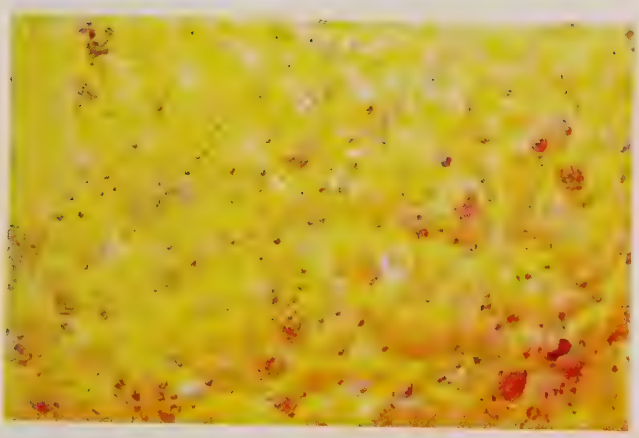
California Red Scale *(Aondiella aurantii* Maskell)
This reddish-brown scale is up to 2 mm in size and can be found on the stem, twigs, leaves and fruits. Heavy infestation will result in die-back. Encrusted fruits are unattractive.

Florida Red Scale *(Chrysomphalus ficus* Ashm.)
This species is found on hundreds of different host plants. At the feeding sites on leaves and fruits yellow spots appear. The scale is up to 2.3 mm in size and is brown or red-brown. It consists of three rings; the outer ring being darker than the central part. The scale cover can easily be separated from the yellow insect body. At 28° C the life cycle takes about 28 days at 16° C it takes 78 days. Many parasites and some Ladybird beetles feed on the Florida Red Scale, which is far less common in Kenya than the California Red Scale.

Citrus Snow Scale *(Unaspis citri* Comst.)
This scale infests primarily the branches of the tree and it can have several generations per year. As a result of prolonged infestation, fruit production is reduced and branches may die-back. The white male insects tend to congregate. The adult female is dark brown and its scale has an oyster shape with one longitudinal ridge in the middle; the male cover, about 1 mm in length, is white with 3 typical longitudinal ridges.

Citrus Mussel Scale *(Lepidosaphes beckii* Newm.)
This species is also found on some ornamental trees. The shape of the scale resembles a mussel, and both sexes are brown. Although the symptoms on leaves and branches are similar to those caused by Snow Scale, this species also attacks the fruit; infested patches failing to colour as the fruit matures. It prefers densely foliated trees. There are at least 3 generations per year.

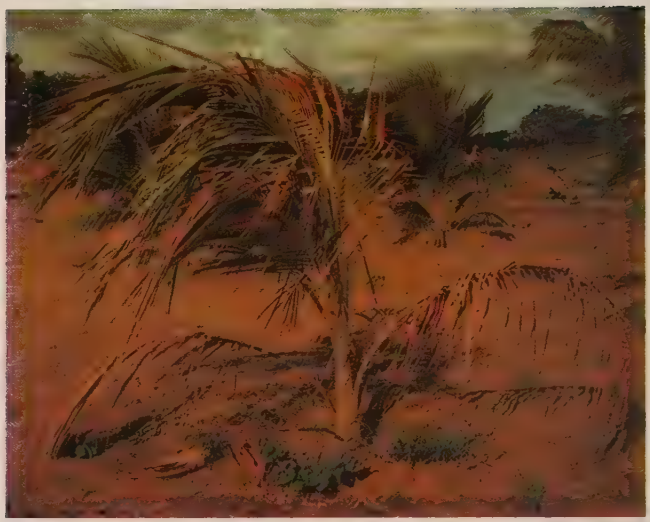
Control Most scales (except Snow Scale) can be controlled by spraying White Mineral Oil until run-off, at 1.75 - 2% emulsion; sprays are most effective on the juvenile stages.



Mineral Oil may be mixed with other insecticides, such as Diazinon or Malathion, using a reduced oil concentration (below 1% emulsion). At higher concentrations mineral oils are harmful to the plant. Preferably, oil sprays should be carried out after picking and not during flowering or periods of excessive heat or drought.

Florida Red Scale, Soft Green and Brown Scale and Snow Scale can be controlled by spraying Diazinon, but only when they are young. Ants, attending and protecting Soft Scales particularly, should be avoided by fixing a dieldrin-saturated cloth around the stem or by spraying Dieldrin around the stem base.

In orchards where effective natural enemies are present, chemical control measures can be reduced by spraying alternate citrus tree rows each season. In this way predators and parasites will survive and help reduce scale attack. Most Scales which have been parasitized show a little round hole in their cover.



Lethal Bole Rot

Marasmiellus cocophilus Pegler

Symptoms This disease is confined to specific localities at the Coast and can be recognised by a number of symptoms. It is primarily a disease of young plants, i.e. less than 8 years old. The earliest symptoms are wilting of the fronds, followed by yellowing and, typically, bronzing. The erect spike dies first with subsequent dying of older leaves from the tip. In older trees the disease can be recognised by the erect dead spike surrounded by the outer leaves and inflorescences dying, but remaining attached. If the crown of the diseased tree is cut lengthwise, a soft rot can be seen which has a very strong smell. This rot is normally confined to the inner

unfurled leaves while the youngest leaves of the bud remain healthy.

At the base of the tree (the bole) there is a dry, reddish brown rot which, in young trees has a distinctive yellow margin. In young trees numerous cavities can be seen in the rotted area, but this becomes less apparent in older trees. Excavation of the roots will indicate a general collapse of the root system without further root production. Small mushrooms may be found growing on infected parts of the tree.

Biology Infection takes place only through wounds in the root system. Apparently the fungus can survive for long periods on coconut debris in the soil, and contaminated soil is the main source of infection, which explains the distribution of the disease in discrete localities.

Control Successful re-establishment of coconuts in diseased areas may be very difficult, so it is vital to restrict the spread of the disease. Because of the root damage resulting from transplanting to the field, great care should be taken in this operation. If roots are damaged they should be pruned out and the plant dipped in a fungicidal solution. One method of reducing this problem is to transplant as early as possible before an extensive root system develops. Of paramount importance in limiting the disease is the avoidance of taking seedlings from an infected area to an uninfected area. The random distribution of the disease in a new planting indicates the probability of nursery infection. In established planting, i.e. more than 8 years old, there may be slow spread from infected trees to neighbouring trees through root contact. In infected areas nursery soil can be sterilized with methyl bromide or dazomet.

As infection takes place through root wounds, cultivation practices which may injure the shallow root system should be avoided. In particular, there should be no cultivation between palms in known infected areas.

Rhinoceros Beetle

Oryctes boas (F) & *O. monoceros* Olivier

Symptoms The adult beetle feeds on the tightly packed, unopened leaves in the central spear. When the fronds open they have large, triangular notches, giving the appearance of the leaves having been cut with scissors. When the midrib is attacked the frond may be broken. A severely attacked palm may die due to the destruction of the growing point, but remains standing. The boreholes through which the beetles enter the unopened leaves are marked with a bundle of fibres and chippings pushed out of the hole.

Biology There are two main species: *Oryctes boas* and *O. monoceros,* the former in tropical Africa and Madagascar

and the latter in Eastern Africa. Whilst coconut is the main host, oil palm, date palm and other *Palmae* are also attacked, and, occasionally, plants not related to *Palmae* may be damaged.

The adult is a large, dark brown, shiny beetle about 4 cm long. It has a rhinoceros-type frontal horn which is well developed in the male but shorter in the female.

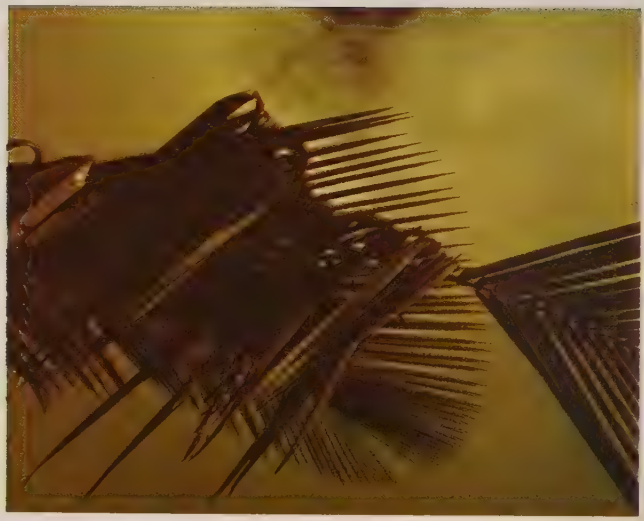
The eggs, whitish brown and measuring 3-4 mm long, are laid in moist, decomposing matter, including trunks of rotting palms. Hatching occurs after 10-12 days. The larvae are whitish, wrinkled grubs measuring about 6 cm. When fully grown they curl up in a C shape and develop entirely in the rotting vegetation on which they feed.

Pupation usually takes place in the soil, but may occur in rotting vegetation or even in a rotting coconut palm which is still standing. The pupa lies in a cocoon or cell composed of soil and aggregated debris, or inside the trunk, it is 4-5.2 cm long, yellow-brown and, if male, with the "rhinoceros" horn already conspicuous on the head. The total pupal period is about 20 days. The adults do not leave the pupal cell for 15 days after emergence. Total life cycle from egg to emergence from the cocoon lasts about 6 months with the female living for another 3-4 months, during which it may lay over fifty eggs. The adults rest during the day and fly for distances of up to 700 metres during the night. The beetles live mainly in the breeding sites.

Control For effective control both cultural and chemical methods should be used together.

Cultural

a) Palms should be planted at the same time at a close, regular spacing so that there is a continuous canopy of foliage; isolated palms of irregular heights are particularly liable to be attacked.



b) Dead and dying palms should be cut down, split open to accelerate drying and burned immediately they are dry, logs and old stumps, dead leaves and all decaying matter should be burned.
c) Wild palms should be removed, split and burned as soon as they are dry.

Chemical

a) In young palm seedlings the leaf axils can be sprayed with diazinon.
b) All possible breeding sites can be treated with Aldrin 40% or Carbaryl 80%, though this can be costly, and care must be taken to avoid poisoning of livestock.

In Kenya and Tanzania a parasitic wasp, *Scolia ruficornis* F has been recorded as a parasite of the beetle but its impact on the population is not known.

The rhinoceros beetle is of major importance in East Africa.

Downy Mildew

Pseudoperonospora cubensis (Berk. at Curt.) Rostow.

Symptoms Symptoms of downy mildew are entirely foliar as no other plant parts are affected. The infected area is irregular in shape and on the upper surface is pale yellow, but the undersurface of the lesion is covered by a purplish grey area of sporulation, most notably in damp weather. As the lesion ages, the leaf tissue dies from the centre outward. On cucumber, the lesions are angular due to being confined by the veins, but this is not so on other cucurbits. The most susceptible foliage is that between 1 and 2 weeks old.

The entire leaf may die resulting in small fruits of poor quality, but when severe, downy mildew can kill the whole vine.

Biology Downy mildews in general prefer cool conditions but the species occuring on cucurbits has a warmer temperatures range. Humidity or free water is, however, a more important factor than temperature. Sporulation reaches an optimum at 15°C and infection is greatest between 16°C and 22°C. Sporulation and infection both occur through the stomata, which are most numerous on the under surface of the leaf.

Spread is primarily by wind.

Control New crops should not be planted before an earlier crop has been completed and destroyed as the young leaves would be vulnerable to existing infection. Dithiocarbamate fungicides are the control chemicals of choice and should be applied every 4-10 days. The more frequent spraying should be used when moist cloudy conditions exist.

Some cucumber cultivars are susceptible to copper toxicity so copper sprays should not be applied to the whole crop before a few plants have been tested for phytotoxicity. Because of the effect of microclimates, too close cropping should be avoided.

Powdery Mildew

Sphaerotheca fuliginea (Schlecht. ex Fr.) Poll.
Poll.

Symptoms Symptoms are similar to those of all powdery mildews, starting as round, white spots on the underside of older leaves. These spots may then enlarge, increase in number and gradually coalesce until the whole surface area, both upper and lower surfaces, are covered. The spots are covered with a white, mealy or dusty deposit of spores. Severely affected leaves dry, turn brown and become papery; causing premature senescence.

Stems and petioles may also be attacked and become covered by spores.

Biology Powdery mildew is a disease encountered more in the dry season than during the rains, as the spores need a humid atmosphere to germinate, but will not do so in free water. The spores germinate optimally at 28° C, but will not do so above 31° C. The generation time, i.e. the time between infection and sporulation, is extremely short and may be as little as 4 days. For this reason an epidemic can develop very rapidly under the right conditions.

Theoretically, two types of spores can be produced, those constituting the white mealy deposits (conidia) and spores produced in minute black flecks on the same lesion (ascospores), but the latter are very rare in Kenya. If produced at all it is late in the crop and of no consequence in disease development.

Control Control is normally with fungicide sprays of which a very wide range exist. Dinocap has proved very successful but the MBC group of fungicides (e.g. Benomyl, Thiophanate methyl etc.) have achieved superior results with fewer applications though there is always a risk that the pathogen may develop resistance to this group when these chemicals are used over a long period.

Increasing the humidity among the plants by irrigation will effectively reduce the incidence of powdery mildew, but this is not recommended in areas where downy mildew is prevalent.

The main effect on yield is a quality reduction due to premature ripening rather than any loss in weight or fruit numbers.

Virus Diseases

1. Cucumber Mosaic — (Cucumber Mosaic Virus)
2. Squash Mosaic — (Squash Mosaic Virus)
3. Watermelon Mosaic — (Watermelon Mosaic Virus)

Symptoms Field symptoms of these three diseases on cucurbits are practically the same. It is therefore, not generally possible in the field to separate them by symptoms alone. The affected leaves are mottled (mild light and dark green mottle to conspicuous yellow leaf blade with green blisters) and, in severe cases, are distorted. Leaf distortion resembles injury due to hormone-type herbicides (e.g. 2,4D). Diseased fruits are malformed (slightly to severely misshapen and, in case of melons, their pattern is reduced or

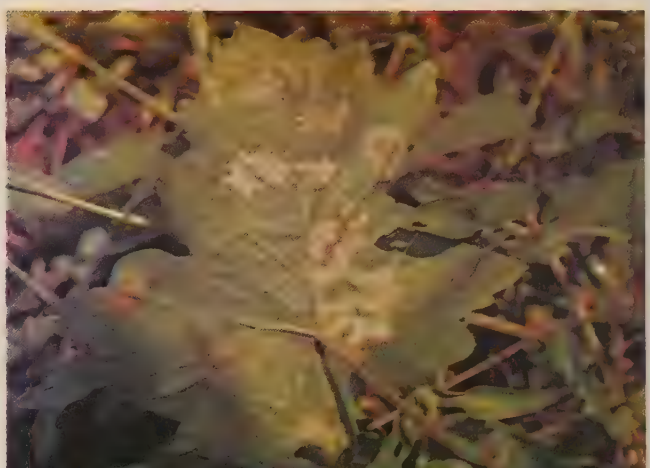
lost. All branches of a diseased plant are normally affected and the new growth is stunted and distorted.

Biology Cucumber Mosaic virus is not seed transmitted, except through the seed of perennial wild cucumber *(Echinocytis lobata)* and chickweed *(Stellaria media).* It is mechanically transmitted and in nature it is transmitted by aphids. Its host range is extensive and includes such varied species as bananas, carrots cowpeas, lupin, lilies, onions, spinach, potatoes, tomato, passion fruit, etc.

Squash Mosaic virus is mechanically transmitted and in nature is transmitted through seeds of melons and squashes and by spotted and striped cucumber beetles.

Watermelon Mosaic virus is mechanically transmitted, and is also transmitted by aphids (melon and green peach aphids). It is not seed transmitted. Several genera of cucurbits may be infected by this virus.

Control Regular insecticidal sprays (see Brassica - Cabbage aphids) to control the insect vectors (aphids and cucumber beetles) and roguing of diseased plants are recommended. Efforts should be made to keep the fields free from weeds as far as possible. Some cucumber varieties are resistant to Cucumber Mosaic Virus but these do not include those currently available in Kenya.



Downy Mildew

Plasmopara viticola (B. & C.) Berl & De T.

Symptoms All parts of the vine except the roots and mature wood are attacked by this major disease of grapevines. Soon after infection it is difficult to distinguish the lesions from the early lesions of powdery mildew except that they are somewhat larger and often nearly circular. In damp weather, however, a downy fungal growth can be seen on the undersurface of these spots, and with age the spots turn brown. Young shoots and tendrils may also be infected and distorted and flowers may be blighted. If young fruits are affected they initially become whitish, but rapidly darken and dry. Older fruits rot but do not usually have the whitish stage which indicates sporulation of the fungus. Even if the fruits

are not attacked the bunches on diseased vines do not fill well and are rather dry.

Biology Sporulation requires temperatures of 18—28° C and high humidity or free water. The spores are very susceptible to strong sunlight, so sunny days during the rains will help to arrest the spread of the disease. As infection occurs through the stomata, factors affecting the opening of the stomata are important; as the stomata do not open on young leaves, these remain free from the disease until maturity.

Control The famous early fungicide, Bordeaux mixture, was developed primarily for the control of this disease, but it has largely been superseded. Several fungicides are available, including Dithiocarbamates, Phosethyl aluminium and Chlorothalonil, the latter also reduces powdery mildew. These should be applied just before and after blooming and possibly again when the fruit is half grown.

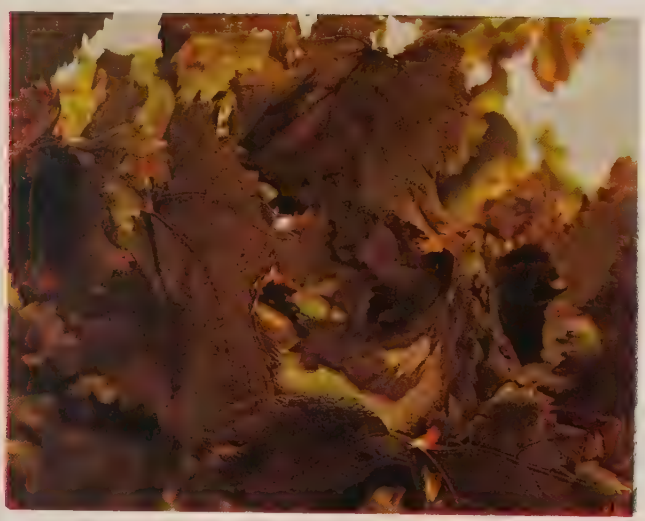
Powdery Mildew

Uncinula necator (Schw.) Burr.

Symptoms Yellow, semi-transparent "oil spots" may be seen on the leaves, which become covered with a thin white layer of spores on the upper surface. Spore deposits may be found on young canes and fruits. The fruits fail to mature and, if severely attacked, characteristically split.

Late in the season the white spore deposits disappear and affected areas turn brown or black. Infection of the young shoots may cause some distortion.

Biology The disease does not usually develop below 1° C and is more serious at 20—22° C. Sporulation, and hence the likelihood of further disease development, increases with



increasing humidity, although direct rainfall may hinder the disease. Light, usually correlated to temperature and humidity, reduces the disease, so it usually seen at greatest intensity in the heart of the foliage.

Control Preventive and curative action against grape powdery mildew is given by sulphur dusts or sprays. Alternatively, fungicides such as Pyrazophos, Dinocap, Binapacryl or several others can be applied. All fungidices should be applied regularly throughout the growing season.

Anthracnose

Colletotrichum gloeosporioides Penz.

Symptoms The disease attacks all tender parts of the tree and is especially severe on flowers, young fruits and leaves. It appears as small black spots on stems, leaves and flower stalks. On flowers and flower stalks, the infection spreads quickly and causes death of individual flowers or often the entire flower stalk. Young fruits are susceptible until they are about half developed. The affected skin areas are usually cracked and slightly depressed. The importance of this disease is particularly post harvest, as on mature fruits the black spots enlarge and a black rot penetrates the flesh.

Biology The principal source of infection is old infected twigs, on which the fungal spores are produced in abundance during damp weather. Spores are principally splash dispersed. Thus rainy weather during blooming and early fruit set is particularly important in disease development.

Control This disease is particularly noticeable in poorly maintained trees and the first step to control is the pruning of dead branches and twigs when this is practical. It can be controlled by spraying periodically from fruit set to harvest with dithiocarbamates or copper oxychloride. Rotting of fruits after harvest can be reduced by holding fruits in hot water (55°C) for three minutes, with or without the addition of Benomyl.

Where feasible, fruits should be stored cool (10—12° C).

Powdery Mildew

Oidium mangiferae Berth

Symptoms Infected flowers, flower stalks, young fruits and leaves are coated with the white, powdery growth of the fungus. The flowers and young fruits turn brown and are shed. In severe attacks, the entire blossom panicle may be infected and the fruits fail to set.

Biology Infection is favoured by cool, cloudy weather, but reduced by rainfall. Spores are disposed by wind from neighbouring early infected trees and survive from season to season in dormant buds.

Control Karathane or Benlate are effective when sprayed immediately before flowering and again three weeks later.

Mango Seed (Stone) Weevil

Sternochetus (Cryptorhyncus) mangiferae F.

Symptoms Mango seeds are damaged or destroyed by the weevil larvae. Infested fruits can drop prematurely, although fruits still on the trees do not show visible external symptoms. On emerging from the ripened fruit, the adult weevil leaves a tunnel which renders the fruit less acceptable on the market. Otherwise the edible part of the mango is often little affected and the weevil apparently does not significantly affect yield, although the tunnel may provide an entry for rot organisms.

Biology No other hosts but mango have been recorded. The weevil is most common at the coast but can also be found in the highlands.

The adult is dark brownish in colour, with some pale patches. It measures nearly 1 cm and has a long, curved snout and black eyes. The female weevil deposits eggs into the skin of developing mango fruits. After hatching, the legless larvae, white with a brown head, bore through the fruit flesh into the young seed, (stone), where they feed until pupation, which also takes place inside the seed.

After the ripened fruits have been harvested or fallen from the tree, the adults emerge from the pupae inside and tunnel through the pulp into the open.

The whole life cycle takes 40 — 50 days.

Control Less susceptible mango varieties, such as Ngowe, Kitovu or Boribo should be selected. All fallen fruits should be collected and destroyed at least twice a week. Before planting, mango seeds should be opened, carefully cutting off the seed husk, and any larvae, pupae or adults found inside should be removed and killed. If the embryo is still viable and fresh, the seed can then be planted.

Mango White Scale

Aulacaspis cinnamoni Newst. (to be confirmed)

Symptoms The white scale insects frequently encountered on mango in Kenya are very similar to the Citrus Snow Scale, but a definite identification has not yet been made. As on citrus, the aggregation of the white males is typical, but damage on mango is done directly to the fruit, rather than to the leaves or branches, as is the case with Citrus SnowScale. The mango white scales are, however, found on leaves.

On green fruits one can observe flat, white (female) scales, more or less circular in shape and 2.5 mm in diameter, although the groups of white male insects are more conspicuous. As a result of sucking by both males and

females, infested spots on the fruit skin turn yellow and become depressed, thereby making the fruit less attractive.

Seen from the side, the male insects hair-like wax secretions resemble fungus growth. Females rarely occur in large numbers.

Biology The adult female is reddish brown, has no legs or wings and lives inside a fixed "scale" which it produces from wax threads. This roundish scale is white except for a dark raised edge on one side.

Reddish eggs are laid under this female scale cover; the hatched "crawlers" later move away from under this cover and wander over the plant until they settle down, inserting their mouthparts into the fruit or leaf and making a "scale" to cover themselves.

The immature males, always found in groups, produce a white cover which is just over 1 mm long and which has three longitudinal ridges. The emerging tiny adult male is dark yellow with black eyes and long antennae; it has one pair of long, rounded wings and it is rarely seen.

Control See under Citrus Snow Scale.

Downy Mildew

Peronspora destructor (Berk) Casp

Symptoms Initially lesions are formed near tips of older leaves and can be seen as elongated yellowish patches covered in a purplish — grey weft of fungus. As a result of these lesions, the leaf tip shrinks and death of the leaf proceeds towards the base and extends to younger leaves.

Similar lesions occur on seed stalks, which, because of the extra weight, tend to snap and seed development is impaired.

Biology Because of the temperature requirements of the fungus, the disease is more serious in the higher, cooler areas of Kenya. The optimum temperature for infection is 13° C and free water and high humidity are also required. The

entire sequence from sporulation to infection usually takes at least two nights, provided that the intervening day is cloudy; the spores quickly lose their vitality in sunlight.

Bulbs are an important means of disease survival in other countries, but in Kenya most onions are grown from seed and the disease has not been shown to be seedborne. On the other hand, onion plants at different stages of development occur on many farms and these permit the survival of the fungus.

Control Most onions are susceptible to this disease, though the red varieties are generally slightly more resistant.

Because of the very good conditions for disease development in many areas where onions are grown, control can be difficult. In order to avoid further increasing the humidity in onion plots, plants should not be sown too thickly and weeds which may impair air movement, should be removed. Onion debris should always be removed from the plot, and crop rotation practised where possible.

Dithiocarbamates fungicides, such as Zineb or Dithane — M45 may be used.

Purple Blotch

Alternaria porri (Ell) Ciferri

Symptoms Whilst onion is the most important host of this pathogen, it also attacks other species of *Allium,* such as leeks and garlic. Symptoms are initially expressed as small white spots on the foliage, which, under moist conditions, rapidly increase to produce large purplish blotches., often surrounded by a yellow to orange border. The lesions then become covered with a sooty deposit of spores. If the lesion extends to girdle the leaf, the leaf collapses and infection may spread to the bulb, where it can cause a wet orange rot, commencing at the neck.

If the foliage is attacked early in the crop, the plants may fail to produce bulbs.

Biology The fungus is seed-borne and also survives on onion debris in the soil. Spores are spread from existing lesions by wind or rain splash; spore production being at its highest in the morning. Penetration of the leaf can be either through the stomata or direct. Whilst high humidity is an important factor in disease development, as it is for downy mildew, rather higher temperatures (25° C) favour purple blotch.

Control It has been observed that varieties with a waxy foliage are generally more resistant than those with glossy leaves. Rotation and the removal of crop debris are also advisable. When the disease is severe, sprays with Dithane M45 or other dithiocarbamates, iprodione or benomyl, give good control.

Onion Thrips

Thrips tabaci Lind. *(Thysanoptera: Thripidae)*

Symptoms The pest feeds at the base of the plant within the leaf sheaths. Attacked leaves have sunken, silvery patches. When the infestation is severe, the entire plant appears silvery and later the leaves wither, dry up and die. The excreta of the insects appears as black spots on the silvery leaves. Hot dry weather apparently favours a rapid increase in thrips numbers as well as the manifestation of the symptoms of attack, while cold, wet weather has the opposite effect.

Biology The main host is onions with tobacco, peas, cotton, tomato, etc. being alternative hosts.

The eggs are whitish and are laid in notches in the epidermis of both the leaves and the stem. Hatching takes 4 — 10 days, depending on the prevailing temperatures. The nymphs are white or yellow and they undergo moulting twice in 5 days, after which they undergo pupation in the soil for 4 — 7 days.

The emerging adult is yellow to brown and has dark transverse bands across both the abdomen and thorax. The adult measures about 1 mm in length. One generation takes about 3 weeks. Both the nymphs and adults rasp the epidermis and suck the plant sap.

On crops other than onions. *T. tabaci* is a vector of tomato spotted wilt virus.

Control The pest may be controlled by spraying with Decamethion, Fenthion or Carbaryl.

Brown Spot

Alternaria passiflora Simmonds

Symptoms On the leaves and vines circular lesions with concentric zones develop, which may result in premature leaf fall. On the fruits the lesions begin as dark green, water soaked spots which become more conspicuous as the fruit develops its purple mature colouration. Fruit infection results in shrivelling and premature drop.

Biology The fungus survives on fallen leaves, and continuing humid weather encourages sporulation and infection. Sporulation on the foliage causes most of the fruit infection, so control measures should be aimed at preventing foliar infection.

Control Fallen leaves and fruits should be regularly collected and burnt. Fungicides such as Mancozeb, Captafol or Iprodione applied at regular intervals during wet weather usually control this disease.

Woodiness
Cucumber Mosaic virus

Symptoms The leaves of the terminal shoots may be stunted, curled, twisted and otherwise deformed. They may develop a yellowish green chlorosis or a definite mosaic of abnormally light green and dark green areas. The tissue of the leaf between the veins may be raised or sunken, thus giving the leaf a puckered or crinkled appearance. The stems of diseased plants, particularly in the region of the terminal shoots, may develop mottled dark green areas which are in marked contrast to the normal green colouration of healthy plants. Diseased fruits are characteristically hardened and are not readily cut through. When they are cut through, the

tissues of the pericarp (rind) will be noticed to be abnormally thickened. Such fruits are often undersized, misshapen and dry.

Biology The virus is easily transmissable by mechanical means and is aphid-borne. A number of aphid species have been reported as vectors of the virus (e.g. *Myzus persicae, Aphis gossypii* etc.). The host range of the virus is very wide (e.g. Cucurbitaceae, Compositae, Liliaceae, Musaceae, etc.)

Control Passion fruit should be propagated by seed. Control aphids with systemic insecticides (e.g. Dimethoate, Oxydemeton-methyl, etc.) and all diseased plants should be carefully rogued out. Efforts should be made to keep the orchard free from weeds as far as possible, as they may harbour the virus and aphids. No resistant varieties are known at present.

Leaf - footed Plant Bug & Giant Coreid Bug

Leptoglossus australis (F) *Anaplocnemis curvipes* F

Symptoms The bugs suck sap from the terminal shoots which wither and die. On fruits the feeding activity is manifested by the appearance of dark, depressed spots around which the fruit becomes hardened in a similar way to that seen in woodiness virus disease. The main difference in the two is that in the case of the former the hardening is confined to a fraction of the fruit, whereas in the latter case, the entire fruit is hardened and malformed.

Biology The adult *L. australis* is brown in colour and measures 2 - 2.5 cm in length. The tibia of the hindlegs bear expansions and the anterior of the mesonotum has a charac-

teristic pale orange stripe across. The antennae are marked by alternating black and pale orange zones. In Kenya this bug is a minor pest of passion fruit and occurs only in the Western region.

A similar coreid bug, *Anaplocnemis curvipes*, occurs East of the Rift Valley. The bug measures about 3 cm in length and is black-brown in colour. The males of *A. curvipes* have abnormally broad hind legs and bear a spine, whereas, in females, this feature is absent. The two species cause similar damage.

Control Except when there is an outbreak, chemical control of these bugs is not necessary. If control becomes necessary, the following insecticides should be used as foliar sprays: Carbaryl, Dichlorvos, Trichlorphon, Endosulfan or Malathion.

Decline

Virus

Symptoms Plants are stunted with fewer leaves which, in turn, are smaller than normal. Symptoms on the leaves vary depending on severity. Vein clearing may be seen on the young leaves, but when infection is severe, these leaves may be badly distorted or crinkled. Occasionally a yellow mottle or spotting is seen. In general appearance of the main stem of the plant becomes distinctly pointed at the apex, resembling a pencil point, and apical death then follows. The effect on fruit is a marked reduction in number and an early fall or withering; the fall occuring soon after fruit set.

Biology Three different viruses, or strains of the same virus, have been associated with this disease, but it is not possible to distinguish between these by symptoms produced on papaya. Two have been detected in papaya pollen, but otherwise, no vector has been found and the disease is apparently not seed-borne. It is possible that transmission could occur by contaminated knives during tapping for latex for papain extraction, but this has never been demonstrated.

Control As virus diseases cannot be controlled by chemical sprays and no vector is known for this disease it is impossible to recommend any control measures. As it is possible that a so far undetected vector exists, the removal of infected trees would help to eliminate the infection source.

Powdery Mildew

Oidium caricae Noack

Symptoms The initially pale spots appear on the leaves which subsequently develop a white, mealy growth on both surfaces as the fungus sporulates. Severely infected leaves turn yellow and fall.

Biology Infection is favoured by cool, cloudy weather. The fungus is continually present but increases during the winter. No perfect stage is known. The spores are spread by wind.

Control Apart from collecting and destroying fallen leaves, little can be done to reduce the disease apart from spraying or dusting with sulphur, should it be felt economical.

Leaf Curl

Taphrina deformans (Berk) Tulasne

Symptoms The disease most frequently occurs on peaches occasionally on apricots, almonds and ornamental *Prunus* species. The symptoms, first appear soon after leaf emergence, with the developing leaves showing pale yellow areas which quickly become dark red, thickened and puckered, leading to leaf curling and general leaf distortion. Later in the season both surfaces of the affected area may become covered with a whitish grey bloom, due to production of spores by the fungus. Infected leaves fall prematurely. If shoots become infected they also thicken and distort, and may die. The destruction of successive growing points may

cause a type of "witches broom" effect by the formation of weak side shoots. Although fruit infection may occur, it is rare and diagnosis is primarily based on foliar symptoms.

Biology Although the disease occurs in practically all regions where peaches are grown, it prefers the cool, high altitude areas of Kenya. In such areas the high humidity and comparatively low temperatures occuring during certain periods of the year favour the development of the fungus.

The spores produced on the surface of infected leaves are capable of surviving several months of hot, dry weather, but are essentially spread by rainsplash. Usually infection of young leaves occurs by the splash spread of spores from twigs and buds, though it is also considered that occasionally infection may spread from twigs through the petiole into the leaf.

Control In severe cases this disease can be damaging. Although an apparent recovery can occur after the premature leaf fall, the new foliage is produced at the expense of the resources of the tree. The whole vigour of the tree, the quality and the quantity of the fruit are affected.

No peach cultivars have commercially acceptable resistance and field sanitation, such as the collection of infected fallen leaves or the removal of infected twigs is not effective except in cases of very mild infection.

Chemical control is, therefore, usually required, but its efficacy is dependent on the timing of the spray. Spraying should be done just before the leaf buds begin to swell, to prevent infection of the young leaves, as cure of already efficiency is dependent on the timing of the spray. Spraying as Thiram, or Copper or Captan are effective, with Difolatan being particularly in high rainfall areas. Where infection is usually severe, a spray with copper after leaf fall is recommended due to its long lasting effect.

Powdery Mildew

Erysiphe polygoni D.C. em Salm. pro parte.

Symptoms A white, powdery coating is seen on the leaves, stems and pods, and, when severe, affected leaves may become chlorotic and the pods discoloured.

Biology This is one of the few powdery mildew diseases which can be seed-borne though its significance is more of scientific interest than practical. Sporulation and spore dispersal take place under hot, dry conditions, whilst infection takes place under humid or wet conditions. Thus the disease is most prevalent in those areas and those seasons when hot, dry days are followed by cool nights resulting in dew formation.

Control This fungus has a very wide host range and it is impractical to eliminate all infection sources, but removal of diseased debris after harvesting considerably reduces the amount of infection material. Without spraying, this disease can cause an almost total loss. Sulphur dusts, or sprays with Tridemorph, Pyrazophos, Triforine or other specific mildewicides can be applied.

Pineapple Mealybug

Dysmicoccus brevipes (Ckll.) (Homoptera: Pseudococcidae)

Symptoms The pest attacks both underground and aerial parts of the plant. On the leaves they feed at the base and their feeding activity is believed to be responsible for yellowing and drying up of the leaf-tips which progresses towards the base of the leaf. On roots the sucking activity is associated with the rotting of the roots and subsequent wilting of the plant. This condition is known as "Pineapple Wilt Disease".

Initially the wilt disease in pineapples was associated with the toxic saliva injected by the mealybug when feeding, but

recent investigations have attributed this condition to a virus disease of the pineapple, transmitted by the mealybug. The symptoms of the disease are cessation of growth and rotting of roots, and collapse of the plant. Fungi of the genus *Phytophthora* isolated from plants having wilt disease were thought to play a role in the wilting, but there is no concrete evidence to support this. Apparently, there is a degree of latency shown by this virus, with infection not immediately resulting in symptom expression.

Biology The main host is the pineapple, although bananas coconut, coffe, sugarcane and wild grasses can also serve as hosts.

The mealybug is pink in colour, measuring about 3 mm in length and covered with a white, waxy secretion and bearing waxy filaments around the body. They live singly or in colonies in leaf axils, roots and around the collar. Normally there is a population increase after a rainy season. The pest has six to seven generations per year. Like all honeydew secreting insects, the mealybug is attended by ants which offer both protection from natural enemies and transportation.

Control Before planting the slips should be dipped in a soluton of Diazinon (16 ml in 10 litres of water) and stacked vertically for 24 hours. This allows the insecticide to accumulate at the leaf base and kill any mealybugs that may be present.

As soon as the Pineapple wilt symptoms appear the crop should be sprayed with Diazinon at the above rate, directing the insecticide towards the leaf axils and the base of the plant. This treatment should be repeated at 3 week intervals until the problem is overcome. The treatment also gets rid of the ants. Incorporation of wetters/spreaders into the spray solution might enhance the efficiency of the chemical. Other insecticides which might be used include Decamethrin, Permethrin, Fenverlate, Fenitrothion and Omethoate.

Grey Mould

Botrytis cinerea Pers. ex Fr.

Symptoms Fruits can be attacked at all stages of development. The first symptom exhibited appears as a light brown, soft spot which later darkens as the rot spreads throughout the berry. The rotting fruit becomes soft, without exuding juice, and then hard and dry. Under moist conditions it becomes covered with greyish powdery mould. This may also appear on leaf and flower tissue.

Biology The causal fungus is widespread on plant material and initially affects the blossoms, bruises, dead flower petals and berries touching the ground. When the spores germinate under favourable conditions of temperature and relative

humidity, the fungus rapidly penetrates the soft tissue of the plant, causing rot. Within a few days the fungus sporulates abundantly on the surface of affected tissues.

Control Plants should be well spaced to permit and encourage air circulation, thereby allowing developing fruits to dry rapidly. The grass or straw mulch should be replaced between crops so that rotting debris is periodically removed. Dithiocarbamate fungicides may be sprayed until fruit set, but after that the fruit flavour may be tainted. Also effective is iprodione, applied at three fortnightly intervals, starting just before the bud opens.

Leafspot

Mycosphaerella fragariae (Tul) Lindau

Symptoms Individual spots on leaves are small, purplish-red lesions. The size of the spot depends a great deal on variety; on some varieties the lesions may remain very small and numerous, giving the leaves a rusty appearance, whilst on others, the lesions enlarge to 8 mm or larger and develop white or light grey centres with reddish-purplish to almost black borders. The leaves, leafstalks, runners and fruit caps are affected. The fungus can also cause "blackseed" of the fruit. Plants lacking in vigour are particularly susceptible.

Biology The fungus is favoured by cool weather and wet conditions. Sporulation occurs in the white or grey centres

of the spots, the spores being distributed by rain drops.

Control Disease free plants should be used when establishing new plantings, which should not be on land on which strawberries were the last crop, i.e. a rotation is important. Resistant varieties should be planted, depending on market requirements, but the disease can be effectively controlled by dithiocarbamate fungicides. A foliar feed helps to improve plant vigour which helps to minimise the disease.

Bacterial Canker

Corynebacterium michiganense (E.F. Smith) Jensen

Symptoms Whilst infection can occur at any stage of the plant's development, it is often in the nursery that this occurs, although symptoms may not be apparent at this time. The first symptom is a wilting and curling of the leaflets, often only on one side of the leaf. These leaflets turn brown and dry, but remain attached to the petiole. The whole plant also often shows a one-sided disease development causing the plant to characteristically lie over. In such a case where perhaps only one stem is infected, the disease eventually progresses to affect the whole plant, which may be killed, but more usually survives until harvest. In addition to the foliar symptoms described, elongated brown strips appear on the stems and shoots which, especially on the stems, dry and crack open to form the cankers from which the disease gets its name.

If an affected stem is cut open lengthwise, a discoloured line should be visible just inside the woody tissue and the pith is easily separated from the wood along this line. The vascular bundles within the pith are destroyed and cavities result.

Young fruits may be infected through the vascular system and symptoms may then range from a slight discolouration of the vascular systems within the fruit to deformation and stunting of the fruit and seed abortion.

More mature fruits may be infected by bacteria splashing onto the surface and the "bird's eye" lesions can be seen, which are very small white spots with a slightly raised light brown canker in the centre, the white halo remains flat. When inoculum is abundant, some of these spots may coalesce.

Biology Bacterial canker is a seed-borne disease which explains its widespread occurence throughout the world, but seed-borne infection is now much rarer in commercial seed lots due to certification of sources and fermentation of the pulp prior to seed extraction. When conditions are optimal for the bacterium, a very low rate of seed infection can lead to serious epidemics.

The causal organism usually survives in debris in the soil, and infects through the vascular system, spreading through the phloem. Spread of the disease within a crop is by splash from rain or sprinklers striking stem cankers. Temperatures above 20° C are considered optimal for disease development.

The organisms can also survive in cracks on sticks used repeatedly for supporting mature plants.

Control No chemical control of this disease is known and no resistant varieties are commercially available, so control depends largely on agricultural practices.

The same nursery site for successive crops should be avoided, in addition to using a field rotation, when this disease is experienced. All crop residues should be burned as the bacteria may survive in debris for more than two years. As the disease can be mechanically transmitted, pruning knives should be sterilized between plants with any commercial disinfectant.

Bacterial canker is encouraged by high levels of nitrate in the soil, so care should be taken not to over fertilize the soil.

Bacterial Spot

Xanthomonas vesicatoria (Doidge) Dowson

Symptoms Although the disease attacks foliage it is most conspicuous on fruit. On foliage irregular, dark green spots, 2—3 mm in diameter, are seen, which eventually dry and the tissue often tears. When severe, defoliation may result. Similarly, if flower parts are infected, serious blossom drop may be noticed.

On green fruits the initial spot is very small and water soaked, but eventually enlarges to about 6 mm and becomes slightly raised. A pale green halo may be seen at first but this gradually disappears. Care should be taken to avoid confusion between these fruit spots and those of bacterial

canker, the halos of which are more distinctly white and the spots are not raised; also the leaves do not wilt as in bacterial canker. As the bacterial spot matures it becomes brown and scabby, without extending deep into the fruit. Ripe fruits are not attacked.

Biology The disease is seed-borne and even a very low rate of seed infection can result in a generalized infection in the nursery. Whilst infected debris can serve as an inoculum source, it is the seed which is considered to be the most important.

Temperatures have little effect on disease development but wet conditions are most important. The disease is spread by splash of rain or sprinkler irrigation.

Infection of leaves normally occurs through the stomata, and on the fruits, infection is through wounds caused by insects or wind-blown sand.

Control Bacterial spot is much less prevalent where furrow irrigation is employed rather than sprinklers. As with many bacterial diseases it is very difficult to control once established in the field, so care should be taken to avoid repeated use of a nursery bed where the disease has occurred in the past.

A mixture of streptomycin and copper sulphate has been effective, but the use of antibiotics in agriculture is not recommended. Copper fungicides may be applied as a protectant when experience shows that the disease may occur.

Blossom End Rot

Physiological

The lesion starts as a water soaked spot at the blossom end of the fruit, enlarging to and becoming dark brown and sunken. The surface of the spot becomes dark and leathery, but there is no soft rot unless the lesion becomes invaded by bacteria or fungi.

Biology The basic cause of blossom end rot is a deficiency of calcium produced by a number of factors not necessarily related to total soil calcium. When the concentration of total soil calcium salts is too low compared to total soluble salts, as occurs with excessive nitrogenous fertilizer application, the amount of calcium taken up by the plant is reduced. The

effective availability of calcium decreases more rapidly than that of other salts in such a situation. The blossom end of fruits are normally low in calcium and are particularly sensitive to calcium deficiency. In particular, calcium is not translocated from older to younger tissues so developing tissue can easily be damaged even when the deficiency is temporary.

An over-riding factor in determining the availability of calcium is heavy rainfall or extreme fluctuations in watering. Heavy rain can bring surface salts applied as fertilizer, into the root area, thereby upsetting the salt ratios referred to above. Also, when growth is rapid, perhaps as a result of heavy application of nitrogenous fertilizers, there is an excessive demand for calcium by the plant and blossom end rot may develop.

Control Calcium deficiency soils should be limed, and nitrogenous fertilizers should be applied sparingly to such soils. Liming should preferably be done before planting.

Whilst proper control of soil calcium should be the main aim in controlling this disorder, blossom end rot can be alleviated by foliar spraying with calcium chloride at 15 kg/1000 L. Higher concentrations may damage foliage.

Early Blight

Alternaria solani Sorauer

Symptoms Early blight may cause symptoms on all aerial parts of the plant, including the fruit.

It is usually the foliar symptoms, however, which are most readily seen. Small, dark brown spots develop on the older leaves, which are generally irregular or angular. As the spots enlarge, up to about 1 cm diameter, they often show a ridged, concentric pattern which distinguishes the spots of this disease from those caused by late blight. The spots are surrounded by a clearly defined yellow area which results, when infection is heavy, in a series of dark brown necrotic spots on a completely yellow leaf. When infection is heavy

late in the season, many leaves die and fall.

If infection occurs on the fruit stems there may be a loss of blossom or of young developing fruits resulting in truss abortion but, on older fruits large, dark, tough spots appear at the stem end of the fruit which extends some way into the flesh. These decayed areas also often show the same series of concentric rings on the surface as on leaf lesions.

Biology The fungus usually survives from one season to the next on dead plant debris, not only of tomatoes, but also of potatoes and brinjals and possibly also on wild species of the same family. Seedling infection generally originates from soil containing infected debris and is encouraged by heavy rain or high humidity and temperatures above 25° C, conditions typical of the long rains. Spread of the spores is, however, enhanced by low humidity and occurs chiefly by wind dispersal.

The survival of the spores on infected debris in the soil is much longer in hot, dry conditions, so the disease is particularly well adapted to the semi-arid areas of the country.

Control This disease is potentially of great importance in tomatoes, due, not only to the reduction of vigour by heavy leaf infection, but also to the infection of the fruits which considerably reduces the quality of the crop. Field losses in excess of 40% have been reported from other countries.

The spores survive for many months under dry conditions, so the inoculum in the soil can be greatly reduced by irrigation and cultivation. Infected plants should be removed early and not allowed to decay in the field. If field sanitation measures are insufficient to provide adequate control, chemical sprays may be used, but full control is not always obtained. Fungicides such as the Dithiocarbamates, Captafol, Chlorothalonil or Benomyl are effective.

Late Blight

Phytophthora infestans (Mont.) de By

Symptoms This fungus also attacks potatoes, occasionally brinjals, but has not been recorded on capsicums. It can cause total loss in a tomato crop if not controlled. Dark brown to black water soaked lesions, surrounded by a poorly defined yellow margin, can be produced on any part of the foliage and these can spread rapidly in damp weather. Additionally, brown streaks or patches may appear on the stems. In damp weather white fungal growth may be seen on the underside of foliar lesions.

Lesions on the fruit may be formed anywhere on the surface, but are most frequently on the upper half. The lesions start as dull green water soaked spots which rapidly enlarge, becoming brown, and then are generally firm and often show concentric raised rings. In damp weather the sporulating fungus may also be seen on these lesions.

Biology Although the fungus causing late blight has been reported as having occured on seed, this is so rare as to be of no consequence in disease development. The fungus does not persist for very long on debris in the soil, so infection occurs usually from neighbouring potato or tomato plots. In moist weather the fungus can spread for considerable distances, so "neighbouring" can be quite far away.

The dispersal spores are produced optimally at 100% RH and about 20°C with infection taking place at slightly higher temperatures. Zoospore germination occurs mostly readily at 12° C and 15° C. Humidity, however, is considered to be a much more important factor for disease development than temperature, and conditions during the two rainy seasons in the Highlands are excellent for late blight development, as can be seen by the very rapid spread of the disease within a tomato crop.

Control Some resistance has been reported in a few varieties, but none of these are yet commercially available in Kenya. Because of the considerable distance over which the disease can travel, field sanitation is of little value, although planting tomatoes after potatoes should be avoided. It is therefore necessary to rely largely on chemical control and spraying should be started as soon as the disease is seen, or, preferably, as soon as experience suggests that the conditions are right for the disease to appear. This is because many fungicides have a preventive action rather than a curative one. Spraying should be done every 7—10 days as long as damp conditions persist. At present the chemicals of choice are Propineb, Mancozeb or Chlorothalonil etc., but Metalaxyl, which originally showed great promise as a cure as well as a prevention, should be avoided in areas where resistant strains have appeared.

***Septoria* Leaf Spot**

Septoria lycopersici Spez

Symptoms This potentially very damaging disease is occasionally seen in Kenya and can occur at all stages from the nursery to fruiting. Small (2 — 3 mm) water soaked spots are first seen on older leaves; these spots become circular with grey centres and black margins. Later tiny black dots are seen on the dead tissue; these are the fruiting bodies of the fungus.

The spots can become very numerous and the leaves then die and drop. As a result of this defoliation the fruits become exposed and are liable to sunscald, although direct infection of the fruit is rarely seen. In severe cases lesions may appear on stems and fruit stalks.

Biology Seed-borne transmission of this disease is very doubtful, but even if it occurs, other factors are much more important. It attacks other Solanaceous plants, including several of the weed species and survives on debris of tomatoes and other weed hosts.

The fungus produces its spores in moist weather, particularly during periods of rainfall, and when temperatures lie between 20 and 27°C. During hot, dry seasons the disease is unimportant.

Control Because of the range of hosts on which this fungus can survive, the removal of Solanaceous weeds is important. The removal of infected debris should be attended to, although the fungus is unable to survive if the debris is dug in deeply.

If infection is seen early in the wet season, and therefore has a considerable time to progress under optimal conditions, the crop can be sprayed with Maneb, Zineb or Mancozeb.

Pesticides

Many fungicides, insecticides, etc., are referred to in this manual for the control of various pests and diseases and it is not possible to list in the text all the various commercial names under which chemicals may be sold, nor whether they are dusts, wettable powders or emulsifiable concentrates, or what concentration of pesticide should be used for any particular disorder or crop. Whilst recommended chemicals have been selected as being among the best available it would clearly be unfair to mention any one manufacturer's trade name and not that of a competitor. It is for this reason that trade names have been avoided in the text. This appendix has therefore been composed to collate much of this information but, for details, particularly of concentrations, the manufacturer's label is usually more detailed.

One important point of information usually lacking from manufacturer's labels, and which extension workers should always emphasize is the pre-harvest interval. This is the period which must be allowed to elapse between the last application and harvest. If such instructions are not followed there is the probability that toxic residues of the pesticide will remain in the harvested crop, thereby presenting a health risk to the consumer. In all other instances the instructions on labels should be adhered to, particularly those relating to precautions to be taken in spraying application.

Used properly most pesticides are fairly safe to use, but care should be taken to avoid contaminating streams and dams, to properly dispose of containers, and to wash hands thoroughly before eating or smoking. It should be part of the responsibility of any officer issuing a recommendation to use a pesticide to emphasize the need for proper and correct use.

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